THE INDIAN FORESTER

(FOUNDED IN 1875)

THE INDIAN FORESTER

VOL. 124 FEBRUARY 1998 NO. 2

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- 8 MAY 1998

ISSN 0019-4816

THE INDIAN FORESTER

Volume 124 **No. 2**

FEBRUARY, 1998

FRONT COVER

SIANG RIVER BANK MIXED FORESTS, PANJIN (ARUNACHAL PRADESH).

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DISTRIBUTION AND GROWING STOCK OF BAMBOOS IN INDIA

S.N. RAI AND K.V.S. CHAUHAN

Forest Survey of India, Dehra Dun (U.P.)

Introduction

It is said "Bamboo is one of those providential developments in nature which like the horse, the cow, wheat and cotton have been indirectly responsible for man's own evolution". Bamboo has been in use since times immemorial. It is perhaps the best known plant in the Orient. It has over 1500 uses and has tremendous versatility. With the rapid socio-economic transformation and industrialisation of the country, it gained importance as a raw material not only for cottage industry but also for large industries like pulp and paper. Therefore, the Bamboo potential surveys have been considered as important as resources survey of timber species. Keeping this in view the Forest Survey of India and its precursor organisation Pre-Investment Survey of Forest Resources (PISFR) started to estimate the Bamboo stock in various inventory surveys since 1965.

Methodology

The Forest Survey of India collects Bamboo data simultaneously in its regular inventory survey of timber species. The inventory work has so far been done under 21 different States covering the entire range of forest types. "Bamboo with trees" is one of the strata. No specific surveys were planned for Bamboo resources alone, with the exception of one in Tripura (Fatikrai catchment) which was mainly Bamboo bearing. In some inventory areas where the Bamboo bearing areas were predominant, the sampling designs for Bamboo stratum was slightly different.

Sampling Design

Systematic cluster sampling design has been mainly adopted in the resources surveys in various areas so far, except in some.

The Forest Survey of India used a cluster of two plots in most of the resources surveys. In Narayanpur Catchment three-plots cluster, in Ballarshah, Sondad and Wadsa Catchment of Chandrapur District and Gujarat survey four-plots cluster and in Bastar District eight-plots cluster design was adopted. A single plot was taken in the surveys of Tripura, Manipur, Orissa and Rajasthan. Square plot of 0.1 ha was generally used.

Bamboo Information

I. *Data Collection (Bamboo)*

Bamboo Enumeration Form (For clump forming) : Total Bamboo clumps (in 0.1 ha

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* Presently Visiting Scholar (ITTO Project), Institute of Forestry, Pokhara (Nepal).

plot) and their respective diameters are recorded in the Plot Enumeration Form (PEF) in the North-West quadrant of the plot. In Bamboo Enumeration form, data of each individual culm occurring in selected clumps in the plot bearing Sl. No. 1, 9, 17, 25 (i.e. the first clump and every eighth clump thereafter) is recorded. Information about clump diameter (from PEF) clump Sl. No. 1, 9, 17... clump size, culm enumeration, their age, soundness, size, condition, average culm height, quality etc. of the clump is obtained and analysed. This form gives the position of total Bamboo stock by clump sizes under various conditions.

Bamboo Enumeration Form (For Non-clump forming Bamboos) : In this form information is collected for non-clump forming Bamboos occurring in the sample plot. For the purpose of counting the culms 1/8 area of the plot (i.e. 1/2 of the North-West quadrant) is taken. Condition, age, average height, total no. of culms etc. are recorded.

Bamboo Weight Form : For determining the relationship between green and dry weight of utilizable Bamboo culm length, data is collected in this form. This form is, however, filled up for plots in which Bamboo is actually found in 2 ha area. One mature Bamboo culm from each culm diameter class 2 to under 5 cm, 5 to under 8 cm and 8 cm and above is selected for felling from first clump enumerated in the plot. If required number or type of culms are not available from first clump, then the shortfall is made good from the clump next to the serial order or from immediate vicinity of the plot. A mature culm means one which has put in more than 2 years of growth. If two species of Bamboo occur in the plot, then both the species are noted as sample No. 1 and sample No. 2. The selected culms are felled at a height of 25 cm from the ground level for each diameter class. The total length of each felled Bamboo culm is measured upto the top, where diameter is just 1 cm. This utilizable length is measured and recorded in cm.

Green weight of the utilizable culms of each diameter class is taken to the nearest 5 cm with the help of weighing balance. Now three 30 cm long pieces from top, middle and bottom portions of the utilizable culms are cut and their green weights recorded. These pieces after noting their diameter class, species code, plots Nos., grid No. and Map sheet No. are tied together and sent to base camp, where their dry weight after every 30 days till 90 days or till weight of pieces becomes constant are recorded.

The occurrence and quality are defined as follows :

Bamboo Cluster :

1. Pure Bamboo	- 200 or more clumps/ha
2. Very dense	- 150-200 clumps/ha
3. Dense	- 100-150 clumps/ha
4. Moderately dense	- 50-100 clumps/ha
5. Scattered	- 25-50 Clumps/ha
6. Sparse	- 1-25 Clumps/ha
7. Bamboo forest but clumps completely hacked by people.	
8. No Bamboo	- Bamboo totally absent
9. Regeneration crop	- Clump formation has not yet taken place.

Bamboo Quality :

(i) Average culm height 6 m or more for *Dendrocalamus strictus* and 14 m or more for *Bambusa arundinacea*.

(ii) Average culm height 4 m or more but less than 6 m for *Dendrocalamus strictus* and 10 m or more but less than 14 m for *Bambusa arundinacea*.

(iii) Average culm height of 2 m or more but less than 4 m for *Dendrocalamus strictus* and 2 m or more but less than 10 m for *Bambusa arundinacea*.

(iv) Regeneration crop.

II. ***Data processing***

Bamboo area : The occurrence of Bamboo species is recorded in Plot Description Form in the area of about 2 ha around the plot centre by quality and density class-wise. Bamboo Area under each quality and density of Bamboo is also estimated from No. of sample plots falling in each quality or density.

Clump Density : Bamboo clumps enumerated by species and diameter class in Plot Enumeration Form are used to estimate the number of clumps per ha by species, quality and clump size (diameter). If there are more than one species, then the separate estimates are obtained for each species.

Table 1

Distribution of Main Bamboo Species in India

Species	States/UTs
Bambusa arundinacea	Arunachal Pradesh, Karnataka, Orissa, Maharashtra, Himachal Pradesh, Andhra Pradesh, Uttar Pradesh and Gujarat.
Bambusa balcooa	Arunachal Pradesh, Mizoram.
Bambusa pallida	Arunachal Pradesh, Nagaland, Mizoram, Tripura.
*Bambusa tulda**	Arunachal Pradesh, Assam, Mizoram, Nagaland, Tripura.
Bambusa polymorpha	Tripura.
Dendrocalamus hamiltonii	Arunachal Pradesh, Assam, Manipur, Mizoram, Nagaland.
Dendrocalamus longispathus	Mizoram.
Dendrocalamus strictus	Andhra Pradesh, Assam, Gujarat, Maharashtra, Himachal Pradesh, Madhya Pradesh,Manipur, Orissa, Karnataka, Uttar Pradesh, Rajasthan.
*Melocanna bambusoides**	Assam, Mizoram, Nagaland, Tripura, Manipur, Meghalaya.
Neebenzia balcooa	Nagaland.
Oxytenanthera nigrociliata	Tripura, Assam.
Oxytenanthera parviflora	Assam.
Pseudostachyus polymorphium	Arunachal Pradesh.
Polystachia pargracile	Orissa.

*These species are non-clump forming.

Table

Bamboo Occurrance

State/UTs	*Bambusa*	*B. arundi.*	*B. balcooa*	*B. pallida*	*B. poly.*	*B.* Species	*B. tulda*	*Dendro. hamiltonii*
Andhra Pradesh	-	-	-	-	-	-	-	-
Arunachal Pradesh	-	*	1	37	-	-	32	29
Assam	-	-	-	-	-	-	-	60
Bihar	-	-	-	-	-	-	-	-
Gujarat	-	44	-	-	-	-	-	-
Haryana	-	-	-	-	-	-	-	-
Himachal Pradesh	-	-	-	-	-	-	-	-
Karnataka	-	34	-	-	-	3	-	-
Madhya Pradesh	-	-	-	-	-	-	-	-
Maharashtra	-	-	-	-	-	-	-	-
Manipur	-	-	-	-	-	-	-	-
Meghalaya	-	-	-	-	-	-	-	-
Mizoram	-	-	*	*	-	5	*	*
Nagaland	-	-	-	13	-	5	25	54
Orissa	67	24	-	-	-	-	-	-
Rajasthan	-	-	-	-	-	-	-	-
Tripura	-	-	-	-	*	-	3	-
Uttar Pradesh	-	-	-	-	-	-	-	-

Note : * denotes that bamboo species is present but their contribution is very small i.e. < 1%

Culms per Clump : From Bamboo Enumeration Form number of culms per clump by age and soundness (green sound, green damaged, dry sound, dry damaged and decayed) are enumerated.

Density of Culms per ha :

(a) *Clump forming Bamboos* - The estimated number of clumps per ha and the number of culms per clump gives the estimate of the number of culms per ha under the various classes of each species.

(b) *Non-clump forming Bamboos* - Enumeration Form contains information of number of culms by age and soundness and further classified by culm diameter classes. This information is used to estimate the number of culms per ha in different classes.

Total Number of Culms : The estimated number of culms per ha and area under particular quality provides the estimates of total number of culms under different classes of clump forming and non-clump forming Bamboos.

Bamboo Growing Stock : Green weight - Weight of freshly felled Bamboo culms of different diameter classes of each species are given in Bamboo Weight Form together

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(in %) by species in India

D. longis	*D.* Spp.	*D. strictus*	DH+ DS	*Malocanna bambusa*	*Neche bal.*	*Oxy Neg.*	Others	BA+ DS	BS+ DS
-	-	-	-	-	-	-	-	100	-
-	-	-	-	-	-	-	1	-	*
-	-	-	-	40	-	-	-	100	-
-	-	-	-	-	-	-	1	100	-
-	-	56	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	100
-	-	63	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	100
-	-	-	-	-	-	-	-	-	100
-	-	-	6	94	-	-	-	-	-
-	-	-	54	46	-	-	-	-	-
*	*	-	-	93	-	-	1	-	-
-	-	-	2	2	1	-	*	-	-
-	-	9	-	-	-	-	-	-	-
-	-	100	-	-	-	-	-	-	-
-	-	-	-	92	-	1	4	-	-
-	-	-	-	-	-	-	-	100	-

with diameter, total weight, utilizable length, top height etc. This information is used to estimate the green weight of Bamboo culms by culm size classes. These when applied to number of culms per ha provide green tonnage of Bamboo.

The following weight factors are applied to obtain equivalent green tonnage of Bamboo :

Green sound	-	1.0
Green damaged	-	0.5
Dry sound	-	2.0
Dry damaged	-	1.0
Decayed	-	0.0

Dry Bamboo Growing Stock : The dry weight factor is considered for specific surveys. By applying this factor green weight, is converted into dry weight. Generally the dry weight is 59-60% of green weight.

Results and Discussion

Main Species : Some of the main species that are found in the country are given in the Table 1, along with their general occurrence in different States. Considering the number of culms the main contributors are *D. strictus* (45%), *M. bambusoides* (20%), *B. arundinacea* (13%), *D. hamiltonii* (7%), *B. tulda* (5%), *B. pallida* (4%) and the

Table 3

Bamboo Area and Growing Stock in India

States/UTs (Year of inventory)	Bamboo Area (km²)	Total Number of culms (million)		Growing Stock ('000 tonnes)		Total Growing Stock
		Clumps Forming	Non-Clump Forming	Clump Forming	Non Clump Forming	
1	2	3	4	5	6	7
Andhra Pradesh (1968-74)	6598	-	-	1612	-	1612
Arunachal Pradesh (1985-90)	4590	867.3	-	9844	-	9844
Assam (1988-90)	8213	1406.6	972.5	12837	568	13405
Bihar (1971-74)	795	-	-	750	-	750
*Goa, Daman & Diu	249	-	-	-	-	-
Gujarat (1977-78)	2806	543.1	-	2540	-	2540
*Haryana	42	-	-	-	-	-
Himachal Pradesh (1974-76)	60	-	-	9	-	9
*Jammu & Kashmir	15	-	-	-	-	-
Karnataka (1983-94)	4925	354.7	-	2162	-	2162
*Kerala	517	-	-	-	-	-
Madhya Pradesh (1970-86)	18124	1426.9	-	9365	-	9365
Maharashtra	8893	1396.6	-	3796	-	3796
Manipur (1986-88)	3692	2593.2	2906.6	811	10659	11470
Meghalaya (1986-88)	3102	260.4	350.3	1007	3400	4407
Mizoram (1988-89)	9210	63.1	6067.3	375	10515	10890

(Contd...)

1	2	3	4	5	6	7
Nagaland (1984-87)	758	488.2	-	3657	-	3657
Orissa (1976-84)	7822	1231.6	-	5290	-	5290
*Punjab	50	-	-	-	-	-
Rajasthan (1984-86)	529	71.5	-	164	-	164
*Tamil Nadu	3101	-	-	-	-	-
Tripura (1989-90)	939	38.0	682.3	51	809	860
Uttar Pradesh (1981-85)	2010	187.8	-	207	-	207
*West Bengal	1751	-	-	-	-	-
Andaman& Nicobar Islands	784	-	-	N.A	-	-
Total	89575	10929.0	10979.1	54477	25951	80428

* Figures of area estimated on forest types basis.

remaining 6% is by other species.

Percentage of Bamboo species in States/ UTs : Percentage of main Bamboo species that are present in India in each State/UT are given in Table 2. In Himachal Pradesh, Madhya Pradesh and Maharashtra *Bambusa* spp. and *D. strictus* are the dominant Bamboo species while in Andhra Pradesh, Bihar and Uttar Pradesh the main Bamboo species are *B. arundinacea* and *D. strictus*. *Melocanna bambusoides* is widely present in Assam (40%), Manipur (94%) Meghalaya (46%), Mizoram (93%) and in Tripura (92%). Rajasthan has *D. strictus* as a main species while in Gujarat it is (56%) and in Karnataka (63%). *D. hamiltonii* is widely present in the States of Arunachal Pradesh (29%), Assam (60%) and Nagaland (54%). As far as *B. tulda* is concerned it is 32% in Arunachal Pradesh and 25% in Nagaland while *B. pallida* is 37% in Arunachal Pradesh and 13% in Nagaland. *B. arundinacea* has a good distribution in Gujarat (44%), Karnataka (34%) and Orissa (24%).

Bamboo areas: The total Bamboo area of the country is 8.96 million ha. Out of this nearly 28% is in the North-Eastern States. In rest of the country the extent in main States is Madhya Pradesh (20.3%), Maharashtra (9.9%), Orissa (8.7%), Andhra Pradesh (7.4%), Karnataka (5.5%) and the remaining 20.1% is in other States.

Growing Stock : The total assessed growing stock (green weight) for the inventoried

areas was 80.428 million tonnes. Of this 67.3% is by clump forming Bamboo and 32.7% by non-clump forming Bamboos. The North-Eastern States have 66% of the total growing stock while the rest of the country has 34%. The main States/UTs that contribute to the growing stock are Assam (16%), Manipur (14%), Mizoram (14%), Arunachal Pradesh (12%), Madhya Pradesh (12%), Orissa (7%), Meghalaya (6%) and Maharashtra (5%).

The green weight and dry weight ratio is 100:60.

SUMMARY

The total forest area of the country is 76.52 million ha. The actual forest cover is 63.96 million ha. The forest area containing Bamboo is 8.96 million ha which constitutes 11.71% of the recorded forest area and 14.01% of the forest cover of the country. The earlier estimate which gave a figure of 9.57 million ha of Bamboo area had considered the recorded forest area of 74.96 million ha (this was the FSI estimate of 1982 which has been widely quoted). From the inventory reports of the FSI carried out from 1965 till now the total growing stock of the country is around 80.428 million tonnes for 8,385 million ha (it is difficult to have precise estimate). This estimate also does not include Bamboos growing on farm lands. the States/UTs which constitute a large proportion of the growing stock are Assam (16%), Manipur 14%), Mizoram (14%), Arunachal Pradesh (12%) Madhya Pradesh (12%), Orissa (7%), Meghalaya (6%), Nagaland (5%) and Maharashtra (5%). Our analysis shows that 66% of the Bamboo growing stock is in the North-Eastern States and the remaining 34% is in rest of the country. The contribution of the clump forming Bamboos to the growing stock is 67.3% while the non-clump forming Bamboos contribute 32.7% to the total. Considering the number of total culms, the contribution of some main species is: *Dendrocalamus strictus* (45%), *Melocanna bambusoides* (20%), *Bambusa arundinacea* (13%), *D. hamiltonii* (7%), *B. tulda* (5%), *B. pallida* (4%) and the remaining 6% is contributed by other species.

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एस०एन० राय व के०वी० एस० चौहान

सारांश

हमारे देश का कुल वन क्षेत्र 765.2 लाख हेक्टेयर है। उस पर लगा हुआ वास्तविक वन 639.6 लाख हेक्टेयर है। बांसों का वन क्षेत्र 89.6 लाख हेक्टेयर है। यह देश के वन अभिलिखित क्षेत्रफल का 11.71 % तथा वास्तिक वन क्षेत्रफल का 14.01% होता है। बांसों के क्षेत्र के पूर्वतम अनुमान में यह आंकड़ा 749.6 लाख हेक्टेयर क्षेत्रफल का 9.57% लगाया गया था। यह 1982 में भारतीय वन सर्वेक्षण द्वारा लगाया गया अनुमान है जिसे बहुत जगह उद्धरित किया गया है। 1965 से आज दिन तक भारतीय वन सर्वेक्षण द्वारा दिखाए तालिका विवरणों के अनुसार देश की कुल वर्धी/संनिधि 838.5 करोड़ हेक्टेयर के लिए 804.28 लाख टन है। इससे ज्यादा सही-सही अनुमान देना मुश्किल है। इस अनुमान में खेतों में उग रहे बांस सम्मिलित नहीं हैं। राज्यों/संधशासित क्षेत्रों में जिनमें इस वर्धी संनिधि का काफी बडा भाग है उनमें असम (16%), मणिपुर (14%), मिजोरम (14%), अरुणाचल प्रदेश (12%) मध्यप्रदेश (12%), उड़ीसा (7%), मेघालय (6%), नागालैण्ड (5%) और महाराष्ट्र (5%) सम्मिलित है। हमारा विश्लेषण दिखलाता है कि बांसों की वर्धी/संनिधि का 66% उत्तर पूर्वी राज्यों में है तथा शेष 34% देश के बाकी भागों में है। बीड़ा बनाने वाले बांसों का योगदान कुल वर्धी/संनिधि में 67.3% है जबकि बीड़ा न बनने वाले बांस कुल संनिधि का 32.7% । कुल बीड़ों की संख्या पर ध्यान देते हुए कुछ मुख्य जातियों का योगदान इस प्रकार है। *डैंड्रोकैलेमस स्ट्रिक्टस* (45%), *मैलोकैन्ना बम्बूसोआयडिस* (20%), *बैम्बूसा अरुणडिनेसिया* (13%), *डै० हैमिल्टोनाई* (7%), *बै० तुल्डा* (5%), *बै० पैलिडा* (4%), और अन्य जातियों का योगदान शेष 6% है।

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REHABILITATION OF GANGA KHADAR AND KHOLA AREAS OF WESTERN ZONE OF U.P. BY UTILIZING TALL PLANTING TECHNIQUE

SHYAM LAL*

Introduction

Western zone of U.P. includes 5 Commissoneries consisting of 22 Districts. Khadar of Ganga are found in 7 Districts. District-wise detail of Khadar areas is given in Table 1. Thus area of Ganga Khadar is situated between longitude 77° 18'E to 79° 35'E and latitude 27° 40'N to 30° 27'N.

Drainage and Slope

The forest blocks are situated in between Doab of Ganga-Jamuna. The drainage is from North-West to South-East. Most of the areas are situated along the flood plains of various rivers specially Ganga. In plains, the drainage is imperfect resulting in water logging/or saline-alkaline patches.

Khadar

These are narrow belts of low lying lands along the upper reaches of the rivers Ganga and Ramganga. They are generally subject to inundation, where ever there is difference in level of the river-bed and their banks, ravines are also found. These areas are subject to regular floods from June to September and are affected by fires in April and May. The summer is very hot and dry, winter is severe with pool frost. The areas are covered with tall grasses such as *Saccharum munja, S. spontaneum* and *Typha angustata* etc.

Khola

Khola is the raised edge of Khadar which is undulating in narrow strips,

Table 1

Distribution of Area

District	Longitude	Latitude	Total Area (ha)	Khadar Area (ha)
Badaun	78° 17' - 79° 32'E	27° 40' - 22° 28'N	6902.00	6000.00
Moradabad	78° 30' - 79°E	28° 20' - 29° 16'N	11921.35	5882.87
Bijnor	77° 58' - 78° 56'E	29° 02' - 29° 58'N	3866.69	3817.90
Meerut	77° 05' - 78° 07'E	28° 49' - 29° 12'N	7992.00	6089.70
Ghaziabad	77° 10' - 78° 07'E	20° 49' - 28° 29'N	2556.00	1800.00
Muzaffarnagar	77° 06' - 78° 12'E	29° 43' - 30° 27'N	9085.00	9085.00
Bulandshahar	77° 18' - 78° 28'E	28° 05' - 28° 33'N	8192.00	4594.40

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running parallel to the flow of current, mainly in dry sandy areas.

Geology, Rocks and Soil

The areas are situated in the Doab of Ganga-Jamuna and its tributaries, mostly underlain by quarternary alluvium made up of sand, silt, clay and scattered Kallar deposits. Soil of many areas is saline and alkaline because of inundation and storage of water. Soil is generally pure sand or loamy sand.

Water level in the Khadar areas is generally with high water table, where wells can be dug easily and water is available for irrigation at just a few metres depth. Chemical analysis of soil of Khadar is given in Table 2.

Climate

The climate is typical of the plains of Uttar Pradesh. The summer is hot, and winter is chilly. Hot wind (loo) blows during summer, winter is quite severe and frost is very common. The following seasons occur in the areas :

(a) *Winter* : December to February - Weather is cold, nights are chilly and frosty. Frost is maximum during January.

(b) *Spring* : March-April - The temperature is moderate and very pleasant.

(c) *Summer* : May-June - Very hot till monsoon breaks.

(d) *Rainy* : July-September - Very sultry and humid; monsoon is most active during this period, sometimes occurs in middle of June.

(e) *Autumn* : October-November- Retreating South-West monsoon, temperature is moderate. Weather is pleasant, characterised by clear sky.

Temperature : The District-wise monthly minimum and maximum temperature in centigrade for four season changing months are given in Table 3.

Thus the minimum temperature is 3.3°C and maximum is 45°C.

Rainfall : With occasional winter showers,

Table 2

Chemical analysis of Khadar soils

Village	Type of soil	pH value	Fossils Carbon (%)	Available Phosphate (kg/ha)	Available Potash (kg/ha)
Hatpura	-	7.65	0.56	4.5	63
Jalolpur Jora	-	7.60	0.49	4.5	83
Sahipur (Forest Block)	-	7.50	0.42	9.0	54
Sarangpur	-	7.55	0.56	4.5	54
Tarbiyatpur	-	7.42	0.21	4.5	68
Average	-	7.54	0.44	5.4	64

the rainfall is confined to the month of July-September. Monsoon usually breaks out by the end of June and last till end of September which results in heavy floods in rivers. Table 4 gives the normal rainfall for past few years.

Natural Vegetation

The area of Khadar and Khola is an edaphic climax. The main vegetation of the area consists of grasses, *Saccharum spontaneum* on slightly higher grounds, in lower areas *Phragmites karka, Arundo donax, Typha angustata, Tamarix dioica, Phoenix sylvestris, Butea monosperma, Ziziphus mauritiana, Acacia farnesiana, Calotropis* spp. and *Lantana camara*.

Injuries to the crops liable to be damaged : Wild animals mainly Blue Bull (*Boselaphus*) damage the crop severely by browsing. Para (*Axis porcinus*) is also found which debarks the saplings.

Table 3

District-wise minimum and maximum temperatures (°C)

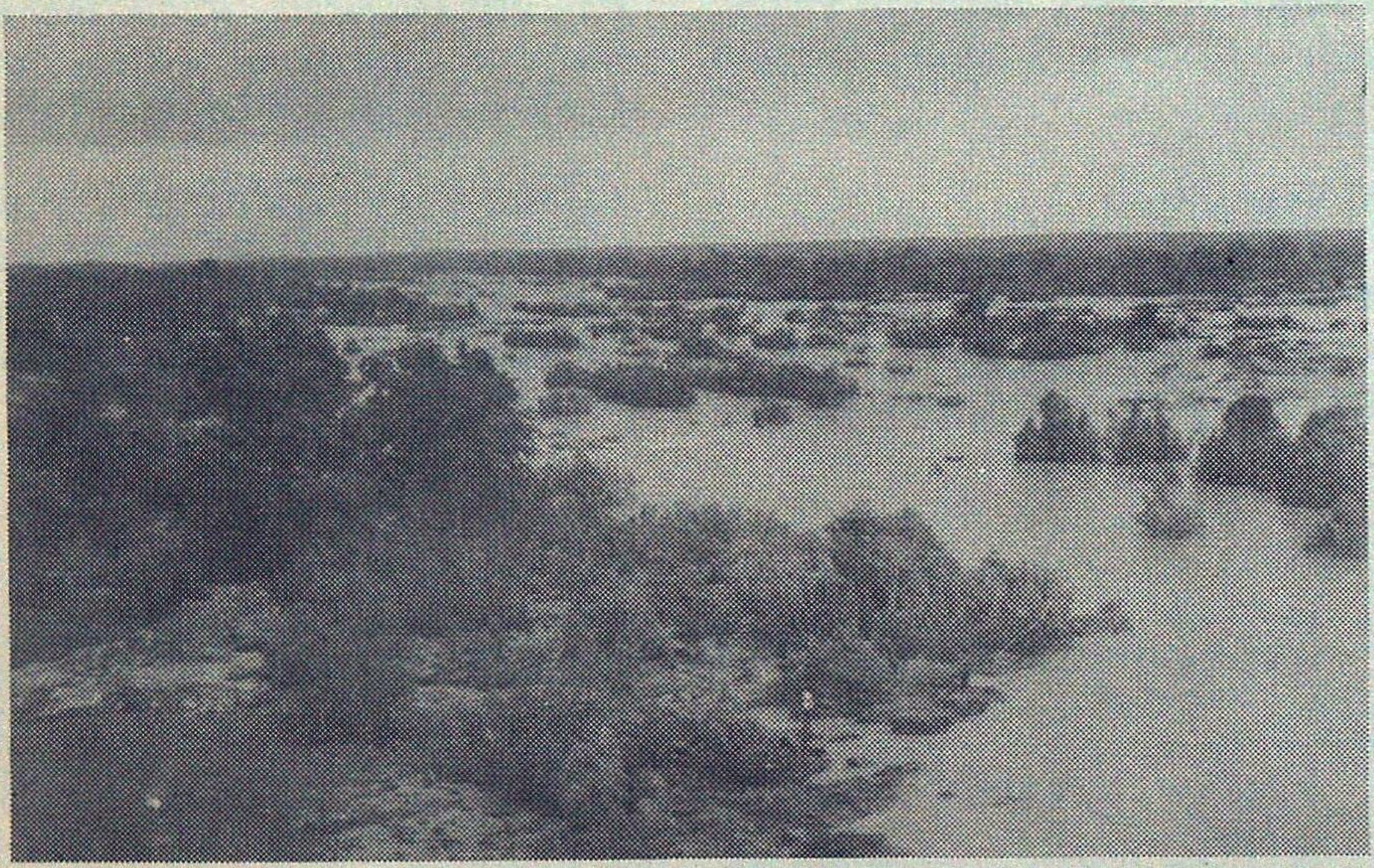
Month	Particulars	Badaun	Moradabad	Bijnor	Meerut	Muzaffarnagar	Buland-shahr
January	Max.	23.30	23.05	23.05	21.0	20.3	18.3
	Min.	3.30	6.05	6.05	7.5	7.2	7.9
April	Max.	31.10	34.00	34.00	36.1	37.1	36.0
	Min.	16.70	21.00	21.00	19.5	20.5	21.0
June	Max.	41.70	43.00	43.00	40.9	43.4	45.0
	Min.	22.00	25.00	25.05	26.9	21.2	25.0
Oct.	Max.	37.60	37.00	37.00	36.0	35.9	36.0
	Min.	17.10	20.00	20.00	18.1	17.5	22.0

Table 4

Normal rainfall data

Station	Normal rainfall at various stations (mm)				
	April-May	June-Sep.	Oct.-Nov.	Dec.-March	Total of Year
	Before Monsoon	Monsoon Period	After Monsoon	Winter	
Badaun	18.00	661.00	24.40	7.00	710.40
Moradabad	16.80	603.20	94.70	11.30	720.00
Bijnor	18.00	627.90	94.00	11.30	720.00
Meerut	21.00	797.00	40.00	16.00	874.00
Muzaffarnagar	22.14	664.00	40.00	19.00	745.14
Bulandshahar	23.00	686.00	81.00	21.00	810.00

Fig. 1

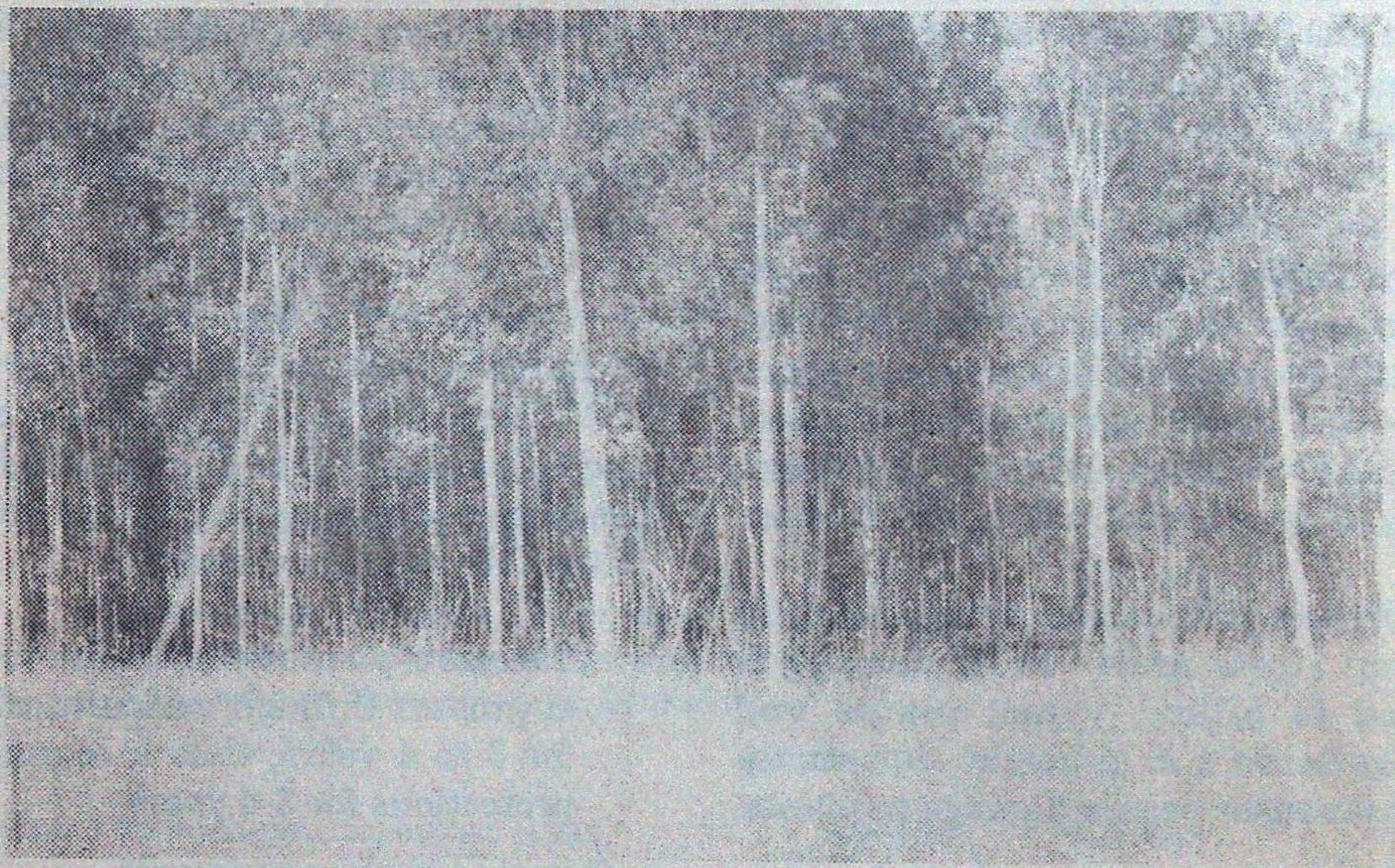


Inundated Khadar area - July 1996

Fig. 2

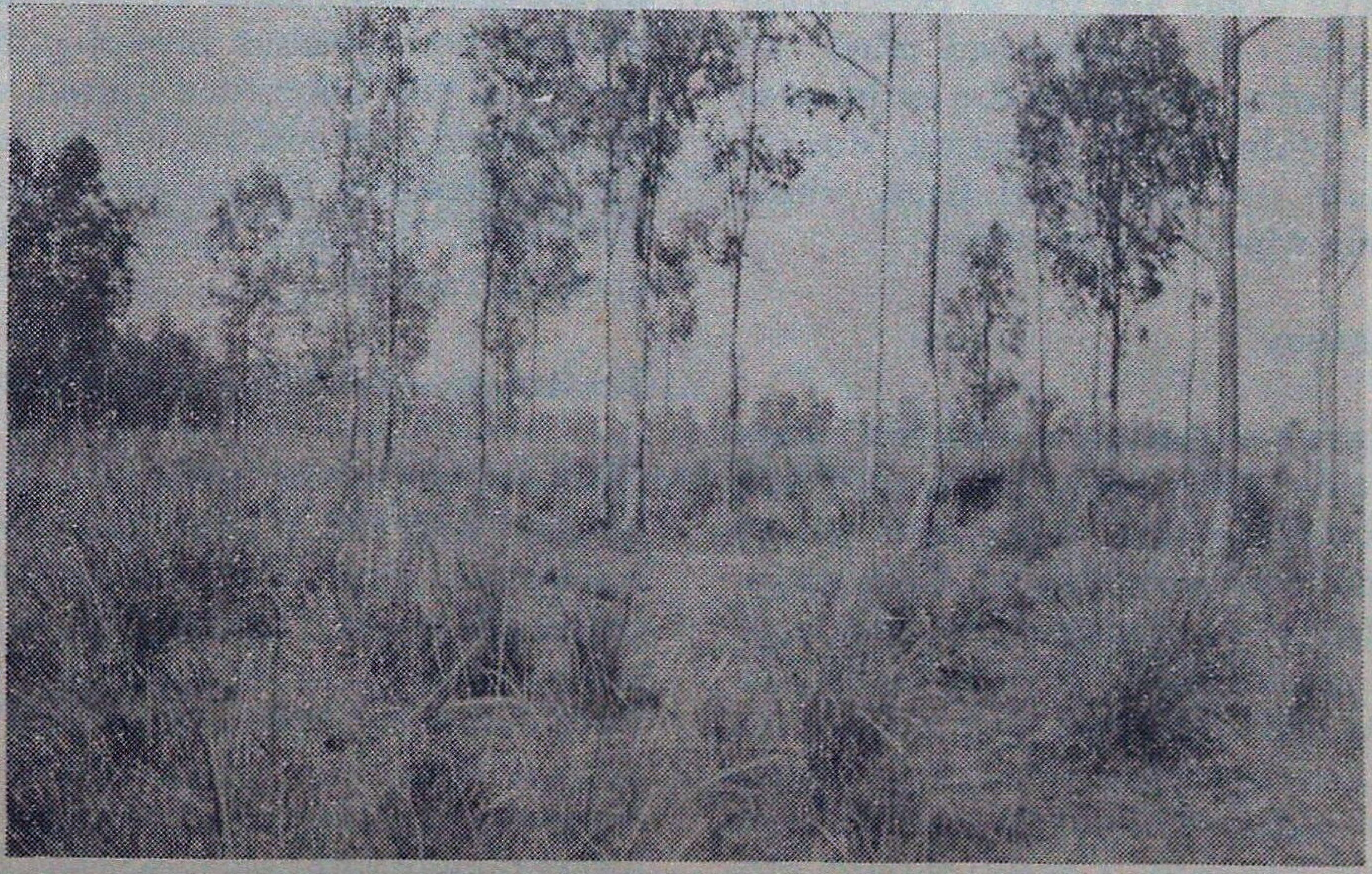
Khadar area after flood - November 1996

Fig. 3



A successful plantation with agriculture lease

Fig. 4



Plantation after coppicing and fire hazard with scattered trees - Dec. 1996

Drought : The area is severely affected by droughts. Plant saplings are affected during summer specially in April-May; also kills the root stock due to desiccation by "Loo". Saplings planted are liable to be killed by extremely hot winds during May-June.

Floods and Erosion : In Khadar areas, frequent floods occur from May to Sept. Some areas remain flooded for 2 to 3 months, which kills the saplings due to submergence under water. Receding water also damages the plants by bending and uprooting them. Cutting of river banks causes soil erosion.

Frost : Frost is quite common particularly in low lying stress areas. Frost damage is confined to killing young plants and seedlings below 2 m in height. Sometimes pool frost causes severe damage to plants.

Storms : During summer, these areas become completely dry, sand starts blowing with winds. Causes uprooting of plants.

Fires : The areas are full of *Saccharum spontaneum - S. munja* and other tall grasses. During April-May the entire area become liable to be damaged due to incendiary and accidental fires, which completely wipe out plantations.

Past History

Efforts for raising plantations were started since 1960 when plenty of funds were available and there was green revolution in forestry through *Eucalyptus*. Mechanised plantations were raised in large areas in almost all the Khadar areas. The main species thus raised were *Eucalyptus* hybrid, *Acacia catechu, Dalbergia sissoo, Bombax ceiba, Holoptelia integrifolia, Pongamia pinnata, Cassia siamia* etc. Mechanised plantations with 3 years leases are successful. But due to lack of protection and lack of funds, accidental fires in the areas cause failure of coppice. Now we have scattered trees with tall grasses. Manual labour plantations with contour trenches were damaged by floods, frost, fire and desiccation hence the plantations so raised are a total failure.

The author of this paper, after taking of charge of Western Zone on 1st November 1995, inspected most of the old successful and failed plantations and tried to find out the causes of success and failure and came to the following conclusions :

1. Success of plantations was due to control of grasses through agricultural leases for 3 to 4 years, thus a complete fire protections for 3-4 years.

2. Failure of plantations was due to fires, frost and browsing by wild animals.

Forest Conservation Act, 1980 do not permit agriculture leases in the area, which in turn allows grasses, browsing, fire and frost and the plantation raised without agricultural crop mostly failed. Table 5 gives list of successful plantations raised from 1980-1997. The list of failed plantations is given in Table 6.

Technique of Artificial Regeneration

Khadar areas with grasses : The areas are infested with tall grasses. In these areas mechanised plantations with one ploughing one patela and two harrowing of the entire areas during Oct. to Dec., leaving all natural trees and shrub species such as *Tamarix dioica, Ziziphus mauritiana, Butea monosperma* after proper pruning, planting before rains or with receding floods. Regular harrowing is needed for control of the

Table 5

List of Successful Plantations

Division	Forest Block	Total Area (ha)	Khadar/Khola	Year
1	2	3	4	5
Meerut	Sahavanpur		Khadar	1986
	Firojpur, Bhirpur Sadhuna, Mishripur		as in	1987
	Sahavanpur, Kharakhali, Mahmudabad			
	Dropadi, Sahadeva, Vidhur, Bastara		as in	1988
	Abhimanyu, Kharkhali, Duryodhan			
	Pandav, Sahipur			1989
	Kaurav, Abimanyu, Bhishm, Bastara			1990
	Kaurav, Karana, Nivada, Saragpur		Khola	1991
	Mukari		Khadar	1992
	Sahavanpur, Pandava, Tarbiyatpur Junav		1993	
	Sahavanpur, Pandava, Vidur, Tarbiyatpur		1994	
	Sahavanpur, Puramhadeva, Mukabari			1995
	Puramahadeca			1996
Bulandshahr	Munishpur, Hasanpur, Ahar,	4024.69	Khadar	1986
	Murshadpur, Kheralibhav, Karoli		as in	1987
	Ahar, Mubarakpur(i), (ii), East Munishpur			
	Hasanpur South, Karoli, Murshadpur			1988
	Karolibhav, Munishpur, Ramghat, H.Pur			1989
	Mubarakpur, Hasanpur, R.ghat, G.gpur			1990
	Kharelibhav, Luksar, Hasanpur			1991
	Karoli Khadar, Ataimuradpur			
	Murshadpur, Kherali, Hasanpur			1992
	Mandihasangarhi, Hasanpur e.s			1993
	Karoli, Ahar, Hasanpur, Munishpur			1994
	Ahar, Munishpur, Mubarakpur			1995
	Luksar, Moradpur			1996
	Murshadpur			1997
Ghaziabad	Alampur, Bhagavantpur, Gadhvali			
	Forest beat, Hakamipuri	547.54	Khadar	1991
	Alamgirpur, Kutubpur, Parsadipur, Gadhavali		1992	
	Alamgirpur, Gadhavali			1993
	Alamgirpur			1995
Muzaffar-nagar	Haidarpur	3652.37	Khadar/Kho	1980
	Kailapur			1981
	Husainpur, Kailapur			1982
	Maralpur, Kailapur, Kasampur, Sikhreda			
	Dhamatpatti			1983

(Contd...)

1	2	3	4	5
	Bhainsaliwala, Kailapur			
	Bhikarhedi, Shukratal			1984
	Firojpur, Bikarhedi, Sikari, Mahanudpua			
	Udivali, Hahalolpur, Panchali			1985
	Haidarpur, Mahamudapur, Sikari			
	Ilavas, Hajipur, Baramada			1986
	Bhikarhedi, Sikari, Hajipur			
	Bhainsavala, Farakhapur, Haidarpur, Nijampur			
	Shivapuri, Mahamudapur			1987
			as in	1988
	Haidarpur, Gokulpur, Tirafpur			1989
	Panchali, Udivali, Dhamatpatti			
	Mahamudapur, Tikola, Gokulpur			1990
	Ayanki, Bahalolpur, Bhainsaval			
	Kelapur, Sikharedi, Shivapuri, Tirafpur			1991
	Bhainsalivala, Kasampur, Sikhareda			1992
	Bhainsalivala, Bhikarhedi, Dariabad			1993
	Tikola, Alampur, Hajipur, Baramada			1994
	Sikhareda, Shahajahanpur, Alampur			1995
	Hajipurbaramada, Kadhivan			1996
Moradabad	Rampura beat c.1to13, eastward	5561.81	Khadar	1991
			as in	1992
			as in	1993
			as in	1994
			as in	1995
Bijnor		3861.64		-
Badaun	Malpur forest beat	1785.76		1979
	Malpur, Ulaikheda, Chandanpur	536.21		1980
	Chandanpur, Taranagla	938.37		1981
	Malpua, Mugerihatei, Chanda	80.13		1982
				1983
	Mugerihatei, Gangapur, Malpur	400.24		1984
	Malpur			1985
				1986
	Gangapur			1987
	Malpur			1988
			as in	1989
	Chandanpur			1990
	Malpur, Khandatarangla			1991
	Malpur			1992
Mathura	Baraunth		Khadar	1981
				1982

(Contd...)

1	2	3	4	5
				1984
				1989
				1992
				1994
	Gulampur (protected forest), Mavali vill, Sadarpur vill			
	Havipur, Shahpur, Navipur, Mahavan			1995
	Sairpur, Daulatpur vill, Dalitpur, Shernagar			
	N. Giradhar, Saidarpur, Mazhoi, Vazipur			
	Gandaya, Latifpur, Ahilyaganj			1996

Table 6

List of failed plantations

Division	Year	Khadar/Khola Forest Beat	Planted Area	Planted Species	Cause of failure
Badaun	1992	Malpur	5	*Eucalyptus, Dalbergia sissoo, Syzygium cumini.*	
Bulandshahr	1992	Hasanpur	20.0	*Acacia nilotica, P. juliflora*	Fires
	1993	Ahar, Hasanpur	17.5	"	Frost
	1994	Mubarakpur Munempur	20.0	"	Floods Browsing
Ghaziabad	1991	Hakimpur Gavadi	18	*Eucalyptus, Dalbergia sissoo Syzygium cumini*	
	1992	Vavtavpur	6	"	
	1993	Alamgirpur	6	"	
	1994	"	3	"	
Meerut	1991	Nivada Saraspur	38	*Dalbergia sissoo, Pongamia pinnata. Acacia nilotica*	
Muzaffarnagar	1993	Majlispur	5	*Terminalia arjuna, Syzygium cumini*	
	1995	Shehyahanpur	33		

grasses, planting of suitable species such as *Holoptelia integrifolia, Dalbergia sissoo, Pongamia pinnata, Acacia nilotica Azadirachta indica, Acacia nilotica, Populus* spp., sowing of *Acacia catechu, Dalbergia sissoo, Azadirachta indica, Bombax ceiba, Pongamia pinnata* is done in 3 x 3 m in pits of 45 x 45 cm on ridges 3 m apart. In summer regular irrigation is needed. Due to shortage of funds the above operations are not being done as prescribed in the working plans.

Considering the paucity of funds for soil working the following four methods were applied :

(1) Ploughing and harrowing entire area and planting 3 m apart on the ridges made.

(2) Ploughing and harrowing in one metre wide strip leaving 2 m wide gap in between and planting on ridges 3 m part.

(3) Digging 45 x 45 cm wide trench across current of water and filling the trenches and clearing 1 m wide strips and burning the remaining grasses and planting 3 x 3 m spacing and sowing of seeds of suitable species along the ridge in two lines.

(4) Digging pits or making mounds 3 m apart and burning the grasses and planting suitable species as above. Planting of tall plants mostly 2-4 m in height was done during June-July 1996. The main species planted are *Dalbergia sissoo, Bombax ceiba, Holoptelia integrifolia, Azadirachta indica, Albizia lebbek, Acacia nilotica, Syzygium cumini* and *Terminalia arjuna*.

Regular weeding, hoeing and cleaning was done as prescribed are within the available budget. The success of plantation as on 31.5.97 is given in Table 7.

Khola Areas : These areas are undulating and slopy, devoid of moisture during summer. Continuous and interrupted contour trenches of 45 x 45 were dug 3 m apart in the blank areas. In the areas having gentle slope intermittent trenches with 2 rows of pits 3 x 3 m apart planting of tall plants of more than 2 m tall was done during July 1996.

In addition to the above, subject to availability of funds, gully plugging with brushwood and small earthen bunds are also needed along with continuous and intermittent contour trenches for moisture and soil conservation.

Protection from grazing from domestic animals is done by protection trenches of 1.20 m wide at top 0.80 m at bottom and 1 m depth along with sowing of *Acacia nilotica, Prosopis juliflora* and *Acacia catechu* seeds on the ridges made by dug up earth. Protection from wild animals such as blue bull is done by spray of mixture of slurry made from blue bull dung, cow dung and gamaxine powder which is effective for about a month during summer and 15 days during rainy season. Binding branches of thorny bushes locally available, on the tip of plants is also very effective. To protect from browsing of wild animals successful plantation can be raised by applying the above methods of protection from browsing by wildlife.

Protection from fire is only possible by harrowing in between the lines in March-April of grass cutting in Feb. or March, with the help of local villagers by allowing them cutting of grasses for their bonafide use as well as for sale. The protection from fire is also possible by allowing the villagers for raising cash crops. Protection from drought and frost is possible by irrigation of plants

Table 7

Success of plantations raised in 1996 as on 31-5-97

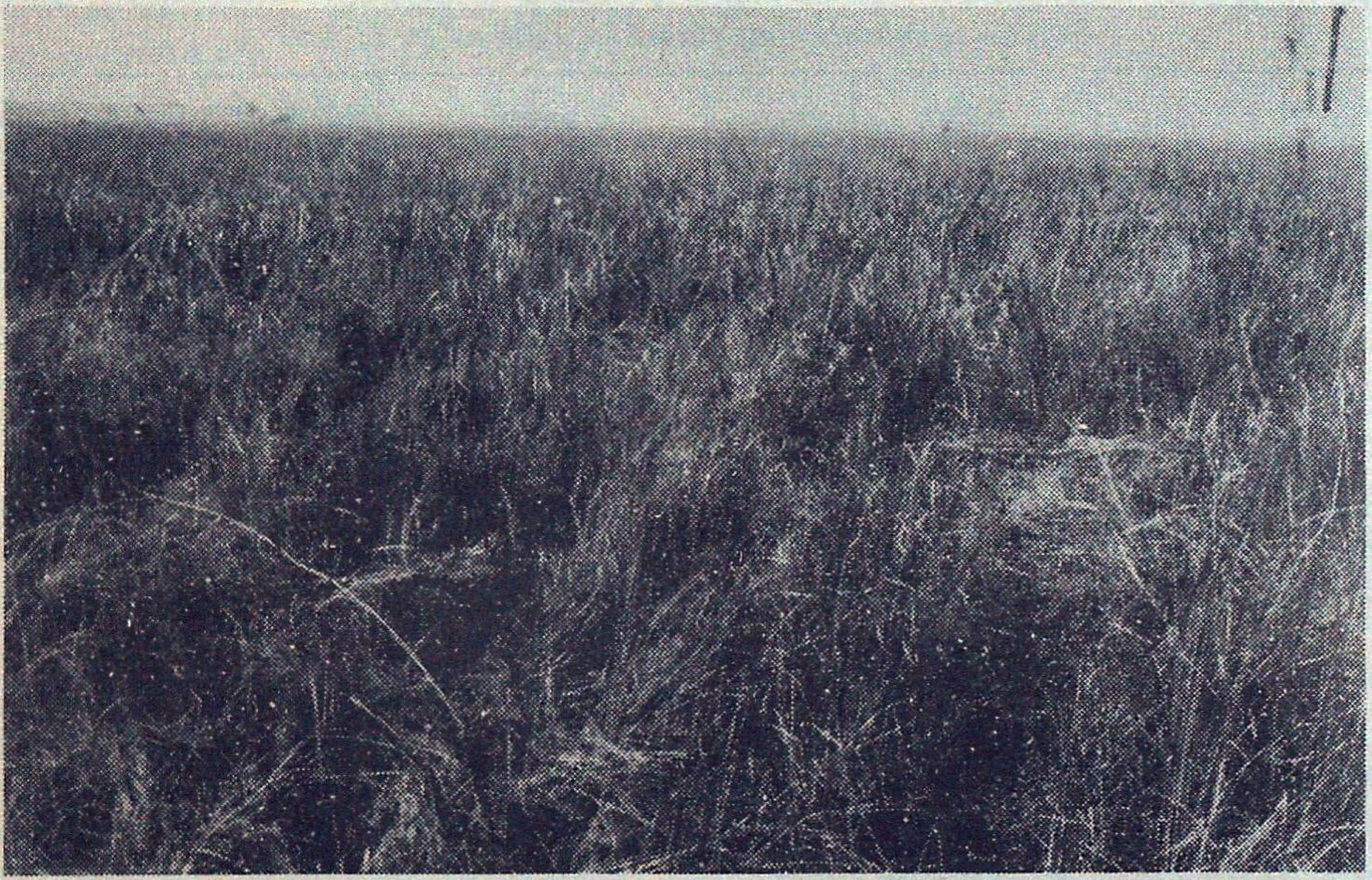
Division	Khadar/ Khola	Block	Area (ha)	Planted Species	Survival (%)	Height (m)	Diameter DBH (cm)
Muzaffar-nagar	Khola Forest	Shukratal	5.00	*Pongamia pinnata, Dalbergia sissoo, Acacia catechu, Acacia nilotica Azadirachta indica*	95	2.5-3	2-3
Meerut	Khadar	Hattpura	4.00	*Terminalia arjuna, Syzygium cumini, Pongamia pinnata, Dalbergia sissoo*	92	2.5-3	2-3
	Khadar	Sahavanpur	5.00	"	95	2-2.5	2-3
	Khola	Jalalpur	10.00	"	90	2-2.5	2-3
	Khola	Sikandpur Forest Beat	11.00	"	68	2-2.5	2-3
	Khola	Barot Aminagar Sarai	5.00	"	87	2-2.5	2-3
	Khola	Jattapur	20.00	"	86	2-2.5	2-3
	Khola	Tarbiatpur Januzi	3.50	"	90	2-2.5	2-3

during summer and winter. This can be achieved by allowing agriculture in the inter spaces, for which irrigation is done, otherwise channel irrigation or use of plastic pipes to reduces moisture losses can be done with minimum expenditure.

Protection from flood was achieved by making ridges or trenches, across the current of river, tall planting of *Dalbergia sissoo, Syzygium cumini, Terminalia arjuna, Azadirachta indica, Pongamia pinnata*, etc. mostly more than 2 m in height in May-June. Winter planting with summer irrigation is also successful. This method was also very effective against frost damage. Severe frost of January 1996 damaged the plants upto 2 m in height but plants more than 2 m were found unaffected by frost in Hatpura plantations of 1996. Planting done in April-May 1996 in Almapur Forest Block with tall plants of *Syzygium cumini* and *Terminalia arjuna*, and cutting of *Salix* has given more than 90% success upto 31 July 1997. Grass cutting in lines will protect the plants from smothering. The experiences of villagers show that harrowing of *Typha angustata* during rainy season will wipe it out.

Sowing of seeds done in February-March has given encouraging result; the height of *Acacia catechu* is more than 30 cm by the end of June.

Fig. 5

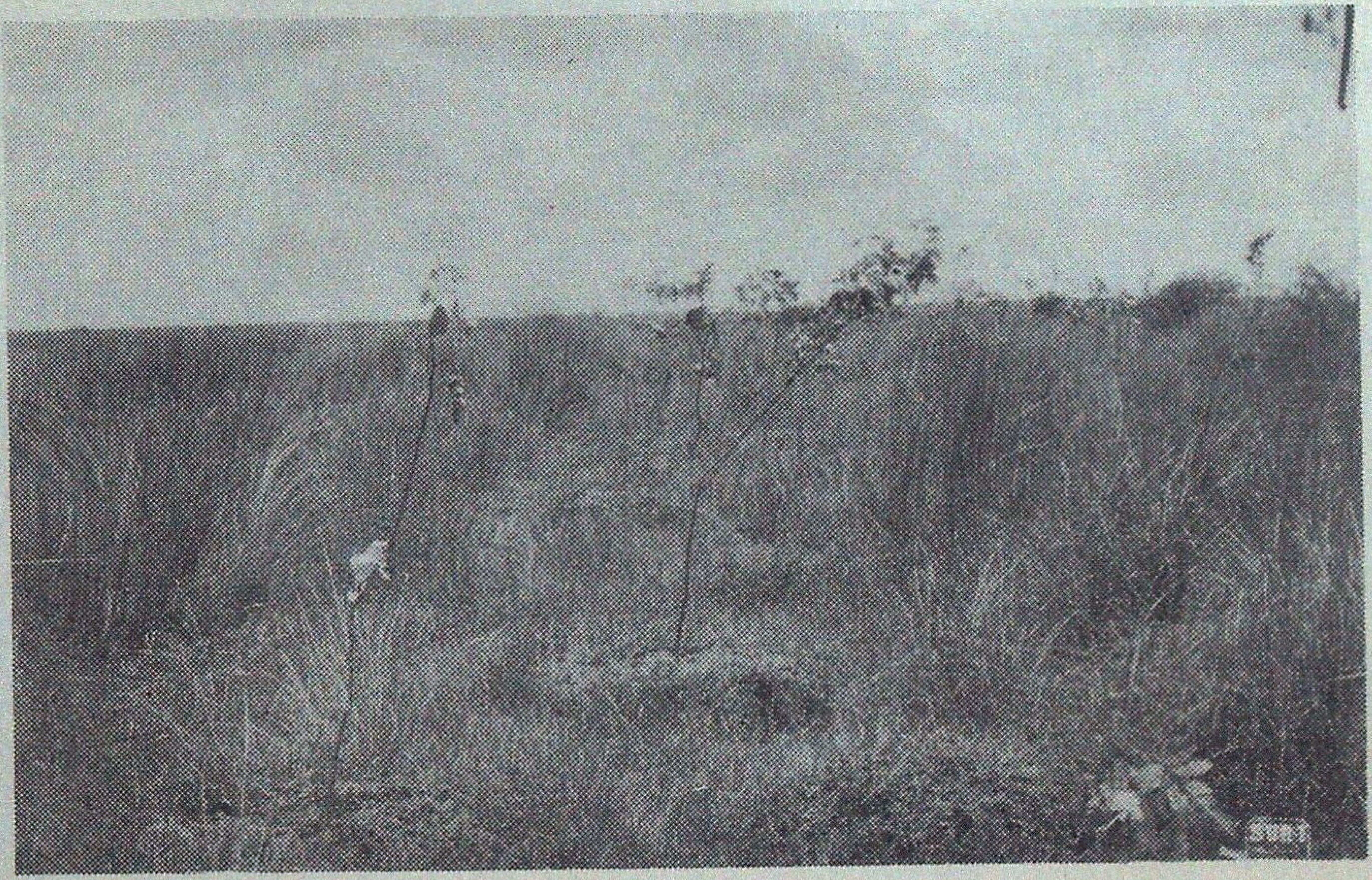


Khadar area in summer - May 1996

Fig. 6

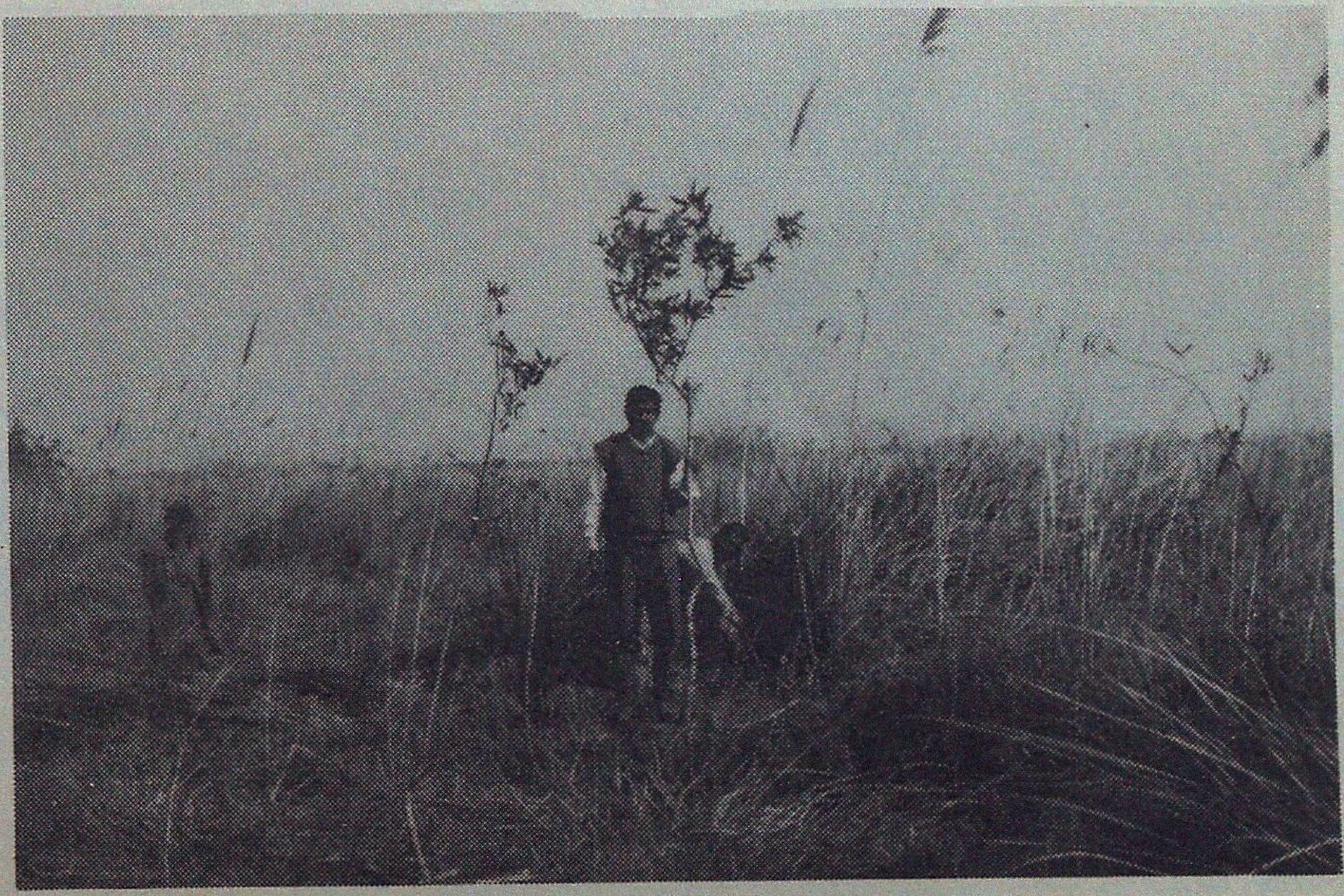
Khadar area with 1 m wide ridge

Fig. 7



Khadar area with tall planting on mounds - Nov. '96

Fig. 8

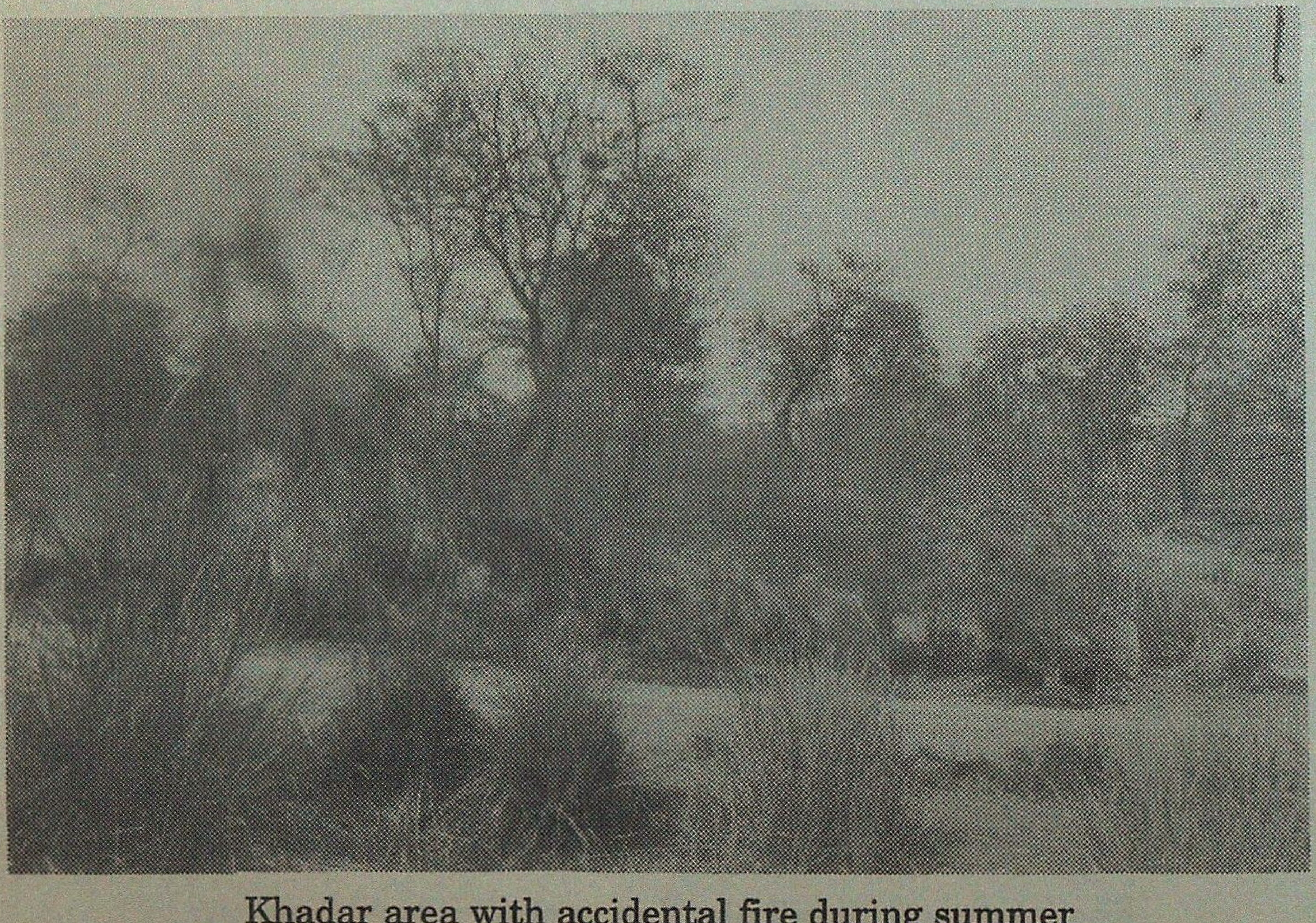


Khadar area with tall planting in clear ridge - June '97

Fig. 9

1995 plantation in Khadar area where villagers are cutting grasses

Fig. 10

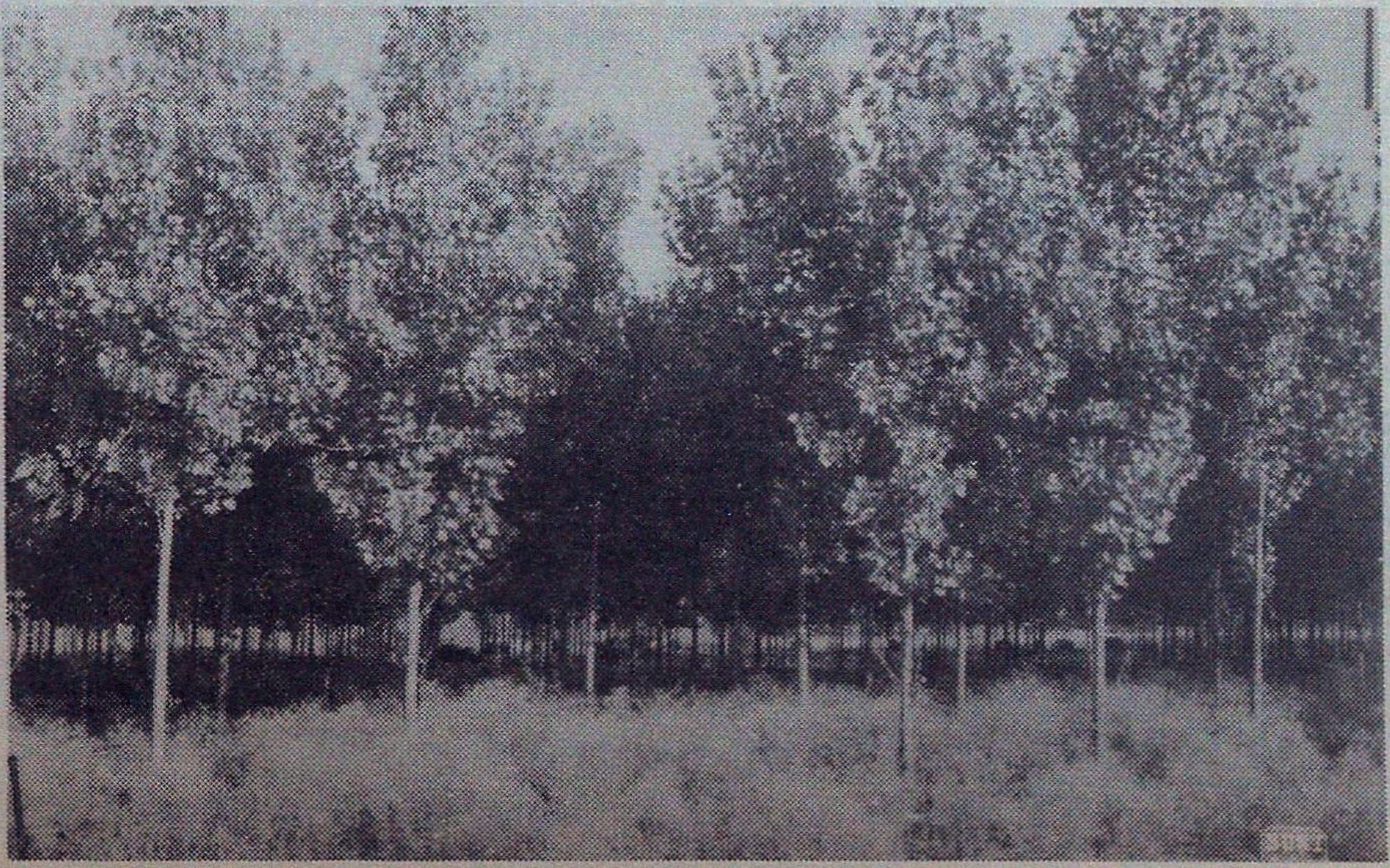


Khadar area with accidental fire during summer

Fig. 11

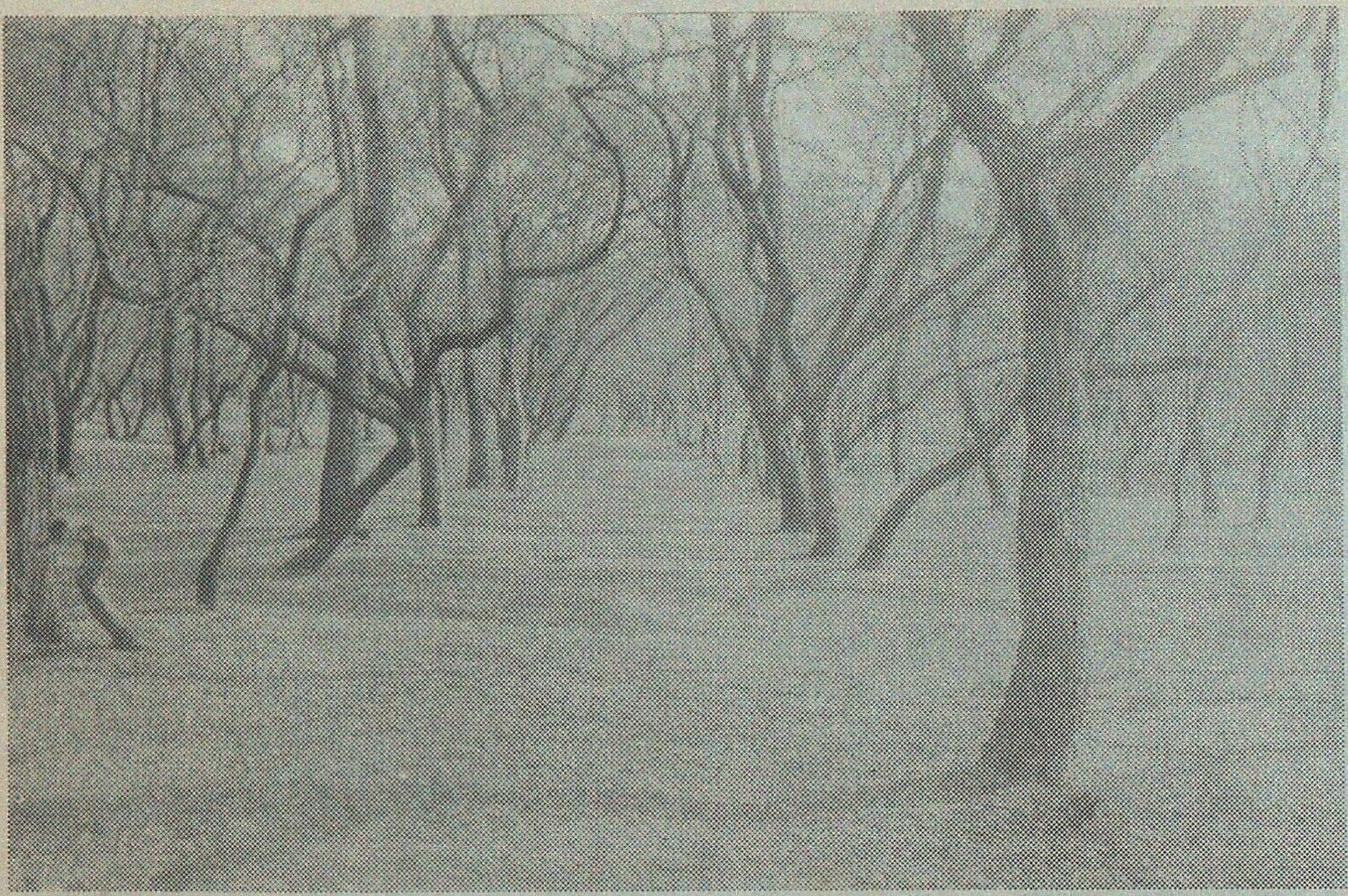
Successful plantation of *Terminalia arjuna* with taungya system

Fig. 12



Khadar area with successful Poplar plantation of 1994 - Oct. '96

Fig. 13



Khadar area with *Acacia catechu* plantation of 1980 with taungya system

Fig. 14

Plantation - December 1996

Making mounds on the low lying areas remains submerged for 2-3 months is also affected from flood damage. Maintenance of plantation which includes weeding, hoeing, irrigations, grass cutting and fire protection is essential at least for 3 years, failing which is the main cause of failure of plantations.

Raising successful plantations in the Khadar and Kholas areas is possible by tall planting of *Dalbergia sissoo, Syzygium cumini, Terminalia arjuna, Pongamia pinnata, Holoptelia integrifolia, Bombax ceiba* and *Albizia lebbek* with sowing of *Acacia catechu, Dalbergia sissoo* and other suitable species along with cover crops, control of grasses by cutting and control burning during February-March.

Use of fertilizers, manure is useful to boost-up the growth rate of plants, thus making them survive with minimum efforts. Mixture of species needs to be planted depend upon the soil texture and intensity and period of water logging. Successful species are *Acacia catechu, Dalbergia sissoo, Bombax ceiba, Holoptelia integrifolia, Pongamia pinnata, Populus* spp., *Terminalia arjuna, Syzygium cumini, Azadirachta indica* and *Acacia nilotica* etc.

The taungya methods of raising plantation with the help of local people specially below poverty line is the solution for rehabilitation of Khadar areas in Western U.P. Afforestation of Khadar areas will increase forest cover and also increase the fuel, fodder and timber production of the area for the local people and raw material for various wood-based industries.

SUMMARY

Tall planting techniques adopted for rehabilitation of Khadar and Khola areas and success of species like *Dalbergia sissoo, Bombax ceiba, Holoptelia integrifolia, Pongamia pinnata, Populus* spp., *Terminalia arjuna, Syzygium cumini, Azadirachta indica* and *Acacia nilotica* are described in detail.

लम्बे पौधे रोपने की विधि उपयोग में लाकर उत्तर प्रदेश के पश्चिमी क्षेत्र के गंगा खादर और खोला क्षेत्रों का पुनर्संस्कार करना

श्याम लाल

सारांश

खादर और खोला क्षेत्रों का पुनर्संस्कार करने के लिए लम्बे पौधे रोपने की विधि अपनाने और उससे डबलर्गिया सिस्सु, बौम्बेक्स सीबा, होलोप्टीलिया इंटिग्रीफोलिया, पोंगामिया पिन्नाटा, पोपुलस की जातियां, टर्मिनेलिया अर्जुना, सायजीगियम क्युमिनाई, अजेडिरेक्टा ईण्डिका और अकेसिया नीलोटिका जैसी वृक्ष जातियाँ लगाने में मिली सफलता का विस्तार से वर्णन दिया गया है।

IMPROVED SEEDLING QUALITY OF POLYBAG PLANTS - USE OF MOUNTED ANGLE IRON BEDS

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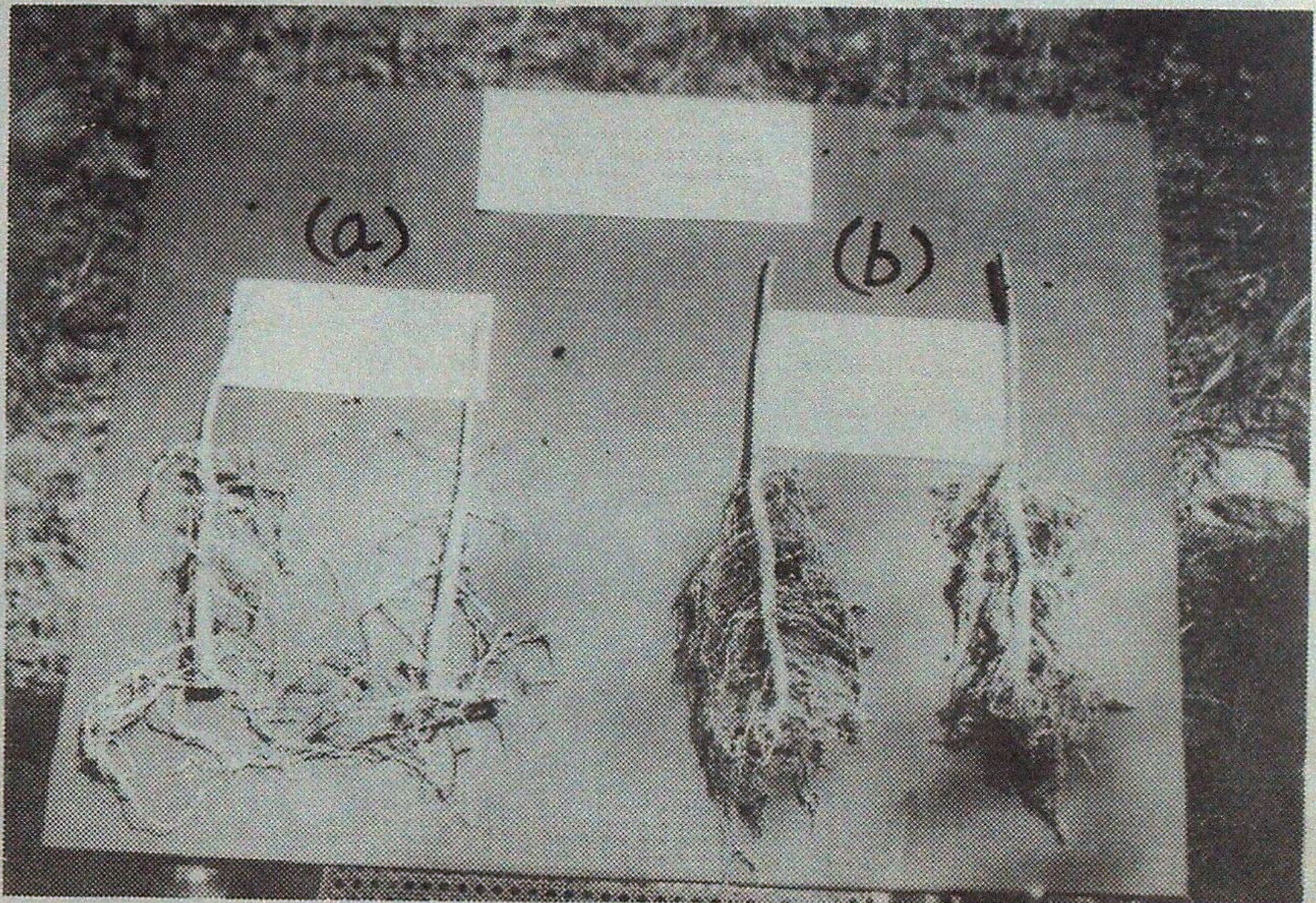
Introduction

In forest nurseries, seedlings are grown either bare-rooted or in containers. A large number of plants are raised in polybags especially in tropical areas. The major advantage of polybag seedling production system is that the polybags carry some amount of potting mix and moisture with them to the planting site, which is often critical for survival of seedlings in the field. The other advantage is that the method is well-established and reliable. However, seedlings raised in smooth, round section containers, i.e., polybags suffer from certain disadvantages, viz., root coiling and distortion. The tap root in polybag when strikes the bottom, fails to penetrate the wall of polybag and in most cases starts coiling at the bottom. A coiled tap root system in polybag acts as a time bomb attached to the root system. The seemingly healthy plant with such a root system fails to withstand even moderate pressure, often resulting in large scale wind throw. Very often the coiled root strangulates itself as it grows, leading to stunted growth and ultimately death of the plant (Gera *et al.*, 1996).

Napier and Willan (1983) suggest that in the coiled roots the basal 1 cm portion of the root cylinder, where the root coils tend to be densest, should be removed altogether before planting. According to Chaturvedi (1994), polybag containers can cause root coiling both at the bottom and at the sides. The damage can be avoided by cutting about 1 cm at the bottom of the polybag and making three 1 cm deep vertical cuts around the bag. These operations just before planting are not always feasible and require some degree of skill and perfection.

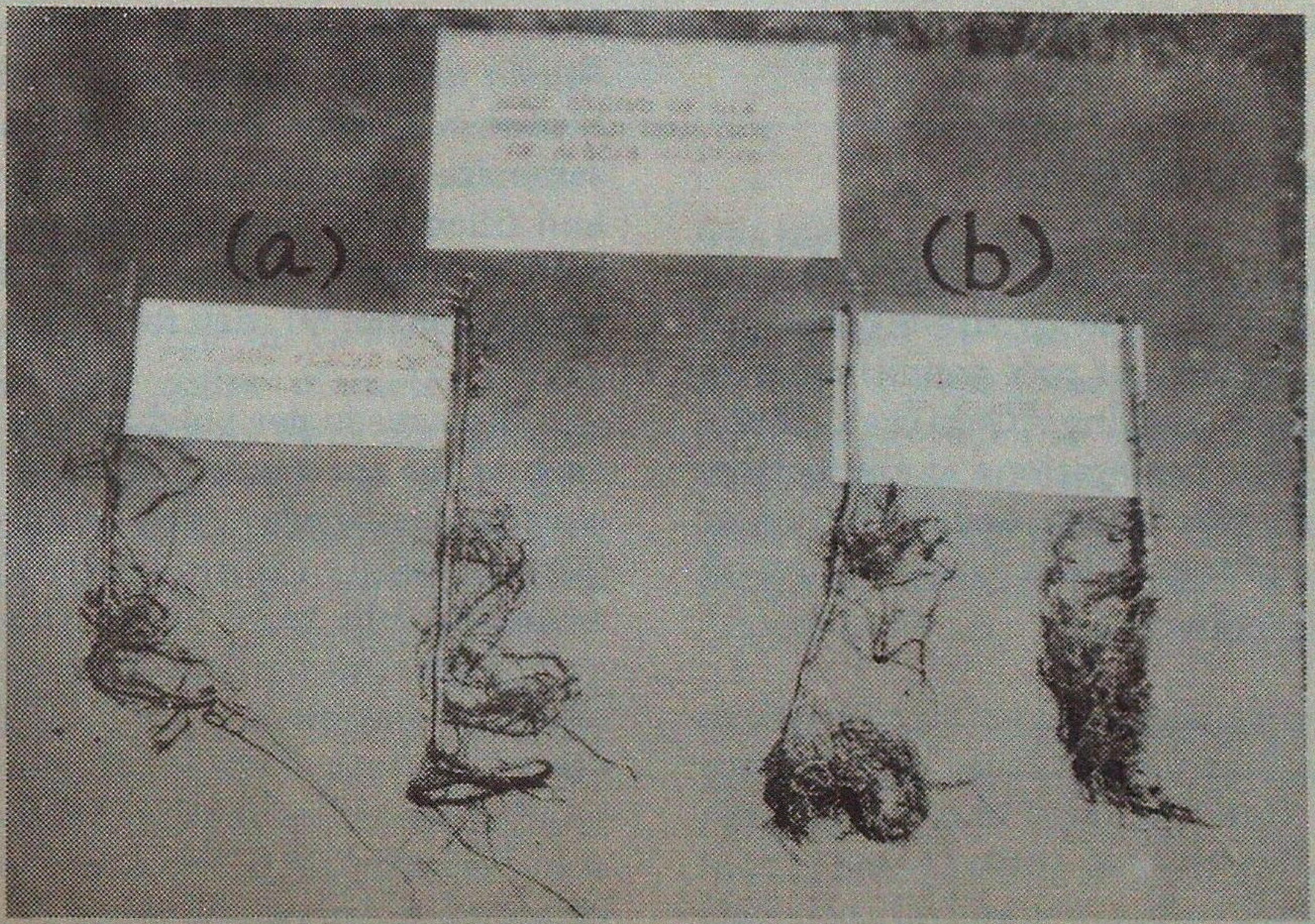
Root trainers are increasingly being introduced to deal with the problems of root coiling and distortion. Root trainers are the containers, usually made of high density polyethylene and designed with 4-5 vertical ribs and have open bottoms. They are either separate tubets or joined into blocks. The most common type is the Hiko tray with 20-25 cavities each having 150 cm^3 volume. However, these are found to be expensive and transfer of plants poses several problems. The plants can not be kept for long and if the potting mixture is not of exact specifications then either the mixture sticks to the pot, making it difficult for the plants to be removed or the ball breaks at the time of removal, resulting in damage to the plants (Chaturvedi, 1996). An attempt has been made at Tropical Forest Research Institute, Jabalpur, to improve the extensively used traditional polybag seedling production system in four tropical

Fig. 1



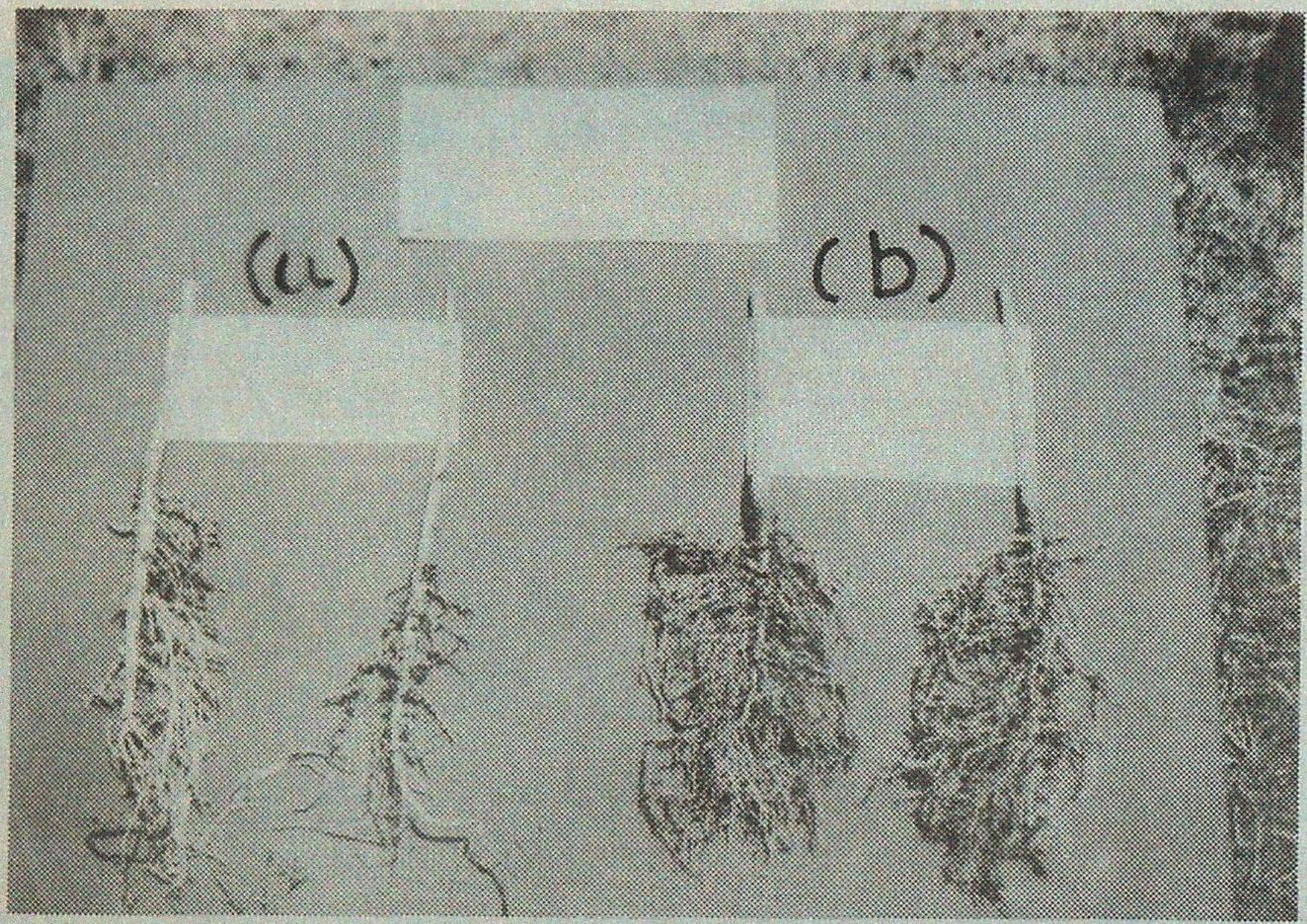
Root system of *Albzia procera* seedlings
(a) Polybags placed on nursery beds, (b) Polybags placed on MAI beds

Fig. 2



Root system of *Acacia nilotica* seedlings
(a) Polybags placed on nursery beds, (b) Polybags placed on MAI beds

Fig. 3



Root system of *Sesbania grandiflora* seedlings
(a) Polybags placed on nursery beds, (b) Polybags placed on MAI beds

species, namely, *Albizia procera, Acacia nilotica, Sesbania grandiflora* and *Sesbania sesban*.

Materials and Methods

Mounted Angle Iron (MAI) beds with wiremesh have been designed and developed with the objective of root conditioning in polybag raised seedlings (Gera *et al.*, 1996). Polybags with perforations at the bottom are placed over these beds, aiming at airpruning of roots when exposed through the perforations.

Six hundred polybags of size 23 x 15 cm with six perforations each of 1 cm diameter at bottom were filled with mixture of Soil : Sand : FYM in the ratio of 1:1:1 and placed on MAI beds. One hundred and fifty polybags (3 replications of 50 each) were used for each of the four species viz., *Albizia procera, Acacia nilotica, Sesbania grandiflora* and *Sesbania sesban*. Another 600 polybags of same size, without perforations at the bottom and filled with similar potting mix, were kept on nursery beds used as control i.e. 3 replications of 50 each for the four species.

Two seeds per polybag were sown for each of the species in February, 1995 and excess seedlings were removed after germination. The seedlings were maintained by regular watering, weeding and other cultural operations. The observations on seedling height, collar diameter, root length, number of roots, number of nodules and dry weights of leaves, stem, primary roots and fibrous roots were recorded in August, 1995.

Table 1

Observations on growth parameters for seedlings of different species placed on nursery and MAI beds.

Species	Polybags placed on	Height (cm)	Root Collar Dia (mm)	Root Length (cm)	Number of Roots	Number of Nodules
Albizia procera	Nursery bed	57.63 ±4.62	5.67 ±0.21	3.60 ±2.55	25.27 ±3.09	24.53 ±4.78
	MAI bed	47.78 ±2.23	5.86 ±0.14	23.06 ±0.81	64.52 ±5.25	75.31 ±7.47
Acacia nilotica	Nursery bed	89.98 ±5.82	5.62 ±0.47	35.22 ±4.64	22.11 ±2.20	09.33 ±2.09
	MAI bed	88.36 ±3.85	5.76 ±0.36	24.44 ±1.79	32.78 ±3.96	20.56 ±5.38
Sesbania grandiflora	Nursery bed	85.49 ±4.84	8.46 ±0.61	29.67 ±4.69	20.60 ±2.91	25.40 ±6.06
	MAI bed	76.11 ±2.38	8.70 ±0.42	21.06 ±1.77	53.33 ±5.52	55.22 ±7.89
Sesbania sesban	Nursery bed	117.89 ±8.69	5.29 ±0.39	40.03 ±7.91	16.33 ±2.90	11.52 ±3.28
	MAI bed	116.60 ±7.80	5.86 ±0.21	16.16 ±3.32	51.67 ±6.68	52.93 ±6.72

Results and Discussion

The observations in Table 1 suggest that height and collar diameter of the seedlings of all species were not affected whether kept on nursery or MAI beds. Interestingly, root parameters and root architecture showed differences when MAI bed seedings were compared with on nursery beds, i.e., control. Root length was higher for control i.e. 30.6 cm, 35.22 cm, 29.67 cm and 40.03 cm as compared to 23.06 cm, 24.44 cm, 21.06 cm and 16.1 cm of MAI beds for *Albizia procera* (S_1), *Acacia nilotica* (S_2), *Sesbania grandiflora* (S_3) and *Sesbania sesban* (S_4) respectively. Number of roots was higher in case of MAI bed seedlings i.e. 64.5, 32.8, 53.3 and 51.7 per plant compared to 25.3, 22.1, 20.6 and 16.3 in case of control for S_1, S_2, S_3 and S_4 respectively. Number of nodules showed the same trend as 75.3, 20.6, 55.2 and 55.9 nodules per plant were recorded in case of MAI bed polybags as compared to 24.5, 9.3, 25.4 and 11.5 in control for S_1, S_2, S_3 and S_4 respectively.

The observations as recorded in Table 2 indicate that no major differences exist in respect of stem biomass, below ground biomass and total biomass. However, leaf biomass is higher in control i.e. 1.27g, 1.32g, 1.22g and 0.50g per plant as compared to

Table 2

Observations on Biomass parameters for different species (dry weight, g/seedling)

Name of species	Placement of polybags	Leaf biomass	Stem biomass	Primary root biomass	Fibrous root biomass	Above ground biomass	Below ground biomass	Total biomass
Albizia procera	Nursery bed	1.27 ±0.87	4.14 ±0.57	7.28 ±8.83	0.49 ±0.21	5.41 ±1.18	7.77 ±0.97	13.18 ±1.67
	MAI bed	0.97 ±0.25	4.31 ±0.53	6.85 ±0.44	1.08 ±0.13	5.28 ±0.73	7.93 ±0.53	13.21 ±1.08
Acacia nilotica	Nursery bed	1.32 ±0.65	8.53 ±1.34	2.51 ±0.80	0.30 ±0.05	9.85 ±1.89	2.81 ±0.74	12.66 ±2.26
	MAI bed	0.93 ±0.15	9.03 ±0.59	2.32 ±0.27	0.79 ±0.08	9.97 ±0.60	3.11 ±0.23	13.08 ±0.74
Sesbania grandiflora	Nursery bed	1.22 ±1.03	5.30 ±1.34	1.50 ±0.41	0.36 ±0.24	6.52 ±2.15	1.86 ±0.58	8.38 ±2.60
	MAI bed	0.92 ±0.21	5.62 ±0.65	1.01 ±0.25	0.94 ±0.22	6.54 ±0.75	1.95 ±0.42	8.49 ±0.94
Sesbania sesban	Nursery bed	0.50 ±0.32	3.84 ±0.60	0.97 ±0.26	0.30 ±0.09	4.34 ±0.83	1.27 ±0.34	5.61 ±0.96
	MAI bed	0.34 ±0.08	4.11 ±0.82	0.66 ±0.16	0.82 ±0.20	4.45 ±0.86	1.48 ±0.35	5.93 ±1.05

0.97g, 0.93g, 0.92g, and 0.34g in S_1, S_2, S_3 and S_4 respectively.

Similar trend was observed in case of primary root biomass. However, fibrous root biomass was observed to be much higher in case of MAI bed seedlings i.e. 1.08g, 0.79g, 0.94g and 0.82g per plant as compared to 0.49g, 0.30g, 0.36g and 0.30g of control for S_1, S_2, S_3 and S_4 respectively.

Roots are geotropic in nature, because of which they grow vertically downwards. However, due to faulty management practices in plants raised in polybags, roots deviate from this natural course and instead, grow either horizontally or vertically upwards or an admixture of both, taking a distorted shape (Sharma, 1987).

The present study has revealed that in case of MAI bed seedling production system, the tap root gets self-pruned and the development of fibrous root growth gets enhanced. Root fibrosity and number of strong first order lateral roots are key morphological attributes affecting seedling performance (Hatchel and Muse, 1990). Nursery treatments to encourage root fibrosity should be adopted and grading of planting stock should include fibrosity (Deans *et al.*, 1990). The improved method of raising polybag seedlings on MAI beds has enhanced the nodulation and fibrosity of the root system in all the species under study.

Acknowledgements

The authors are grateful to Dr. B.N. Gupta, Director and Shri R.L. Srivastava, Head, Silviculture Division, Tropical Forest Research Institute, Jabalpur, for providing necessary facilities and valuable guidance.

SUMMARY

Polybag raised seedlings have many disadvantages viz., root coiling and distortion, scanty lateral root development and frequent shifting operations. To deal with the problem, Mounted Angle Iron (MAI) beds have been designed. Polybags with perforations at the bottom are placed on these beds. The tap root is expected to get exposed through the perforations and air-pruned leading to development of fibrous root system. A trial was carried out to compare the performance of polybag seedlings of *Albizia procera* S_1, *Acacia nilotica* S_2, *Sesbania grandiflora* S_3 and *Sesbania sesban* S_4, raised on MAI beds with those raised on nursery beds. The observations suggest that the seedlings raised on MAI beds recorded higher fibrous root biomass i.e.1.08g, 0.79g, 0.94g and 0.82g per plant as compared to 0.49g, 0.30g, 0.36g and 0.30g of control (nursery bed seedlings) for S_1, S_2, S_3 and S_4 respectively; and number of nodules i.e. 75.3, 20.6, 55.2 and 52.9 as compared to 24.5, 9.3, 25.4 and 11.5 in control for S_1, S_2, S_3 and S_4 respectively. In case of root length, leaf biomass and primary root biomass, the nursery bed raised seedlings recorded higher values for all the four species. No difference was observed in case of seedling height, collar diameter, stem, biomass and total biomass. The improved polybag seedlings production system has enhanced the quality parameters of seedlings i.e. fibrosity and nodulation.

पोलिथीन थैलियों में उगाए पौधों का गुण सुधार - कोनिया लोहे पर बनाई क्यारियाँ उपयोग में लाना

मोहित गेरा, नीलू गेरा, संदीप शर्मा व ए०एस० भण्डारी

सारांश

पोलिथीन थैलियों मे उगाए पौधों में बहुत से दोष रह जाते हैं जैसे जड़ मुड़ना और विकृति, पार्श्विक जडों का कम विकास और बार-बार जगह बदली जानी। इस समस्या से निबटने के लिए कोनिया लोहे पर चढ़ाई क्यारियाँ आकल्पित की गई हैं। तली में छेद बनी पोलिथीन थैलियों को इन क्यारियों पर रख दिया जाता है। इन छेदों में से मूसला जड़ निकलकर बाहर खुल जाती है और हवा में उसकी काट-छांट करके रेशेदार जड़ प्रणाली विकसित करा दी जाती है। सामान्य क्यारियों में उगाए पौधों के साथ ऐसी कोनिया लोहे पर बनाई क्यारियों मे *एल्बिजिया प्रोसेरा* (एस$_1$), *अकेसिया नीलोटिका* (एस$_2$), *सेस्बानिया ग्रांडिफ्लोरा* (एस$_2$), और *सेस्बानिया सेस्बन* (एस$_4$) के पोलिथीन में उगाए पौधों की तुलना करने के लिए एक परीक्षण किया गया। इन प्रेक्षणों से संकेत मिलता है कि कोनिया लोहे पर बनाई क्यारियों में उगाए पौधों में अधिक अच्छी रेशेदार जड़ जैवपुंज बनता अभिलिखित हुआ अर्थात् एस$_1$, एस$_2$, एस$_3$ और एस$_4$ पौधों में क्रमशः क्यारियों में उगाए नियामक पौधों के प्रति पौधे 0.49 ग्राम, 0.30 ग्राम, 0.36 ग्राम और 0.30 ग्राम की तुलना में कोनिया लोहे पर बनी क्यारियों के पौधों में यह 1.08 ग्राम, 0.79 ग्राम, 0.94 ग्राम और 0.82 ग्राम प्रति पौधा पाया गया तथा ग्रन्थाओं की संख्या भी एस$_1$, एस$_2$, एस$_3$ और एस$_4$ में क्रमशः सामान्य क्यारियों के 24.5, 9.3, 25.4 और 11.5 की तुलना में कोनिया लोहे वाले पौधों में 75.3, 20.6, 55.2 और 52.9 रही। जहाँ तक जडों की लम्बाई, पत्तियों का जैवपुंज और प्राथमिक जड़ के जैवपुंज का प्रश्न है क्यारियों में उगाए पौधें के लिए इन सभी जातियों की ये अर्हाएं अधिक पाई गई है। पौधे की ऊंचाई, मूल संधि पर व्यास, तना जैवपुंज और कुल जैवपुंज में कोई अन्तर नहीं पाया गया। परिष्कृत पोलिथीन थैली के पौधों की उत्पादन प्रणाली से पौधों के गुणात्मक सर्वमापों अर्थात् रेशेदारी और ग्रन्थाएँ बनने में उन्नति हुई है।

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VOLUME TABLES FOR *AZADIRACHTA INDICA* FOR GUJARAT REGION

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Introduction

Neem (*Azadirachta indica* A. Juss.) is an attractive evergreen tree native to the Indian subcontinent, but cultivated throughout South-East Asia, Australia, East and Sub-Sahelian Africa, Fiji, Mauritius, many countries in Central and South-America, the Caribbean, Puerto Rico, and the Virgin Islands.

Neem is a very important tree in the Indian subcontinent both culturally and medicinally. It is a fast growing sturdy tree and can be established without irrigation in hot and dry regions with low annual rainfall of 500 mm or less. It grows well on poor, shallow, stony or sandy soils. Plantations of Neem bring improvements in the environment too.

Neem is one of the most valuable multi-purpose species least exploited amongst tropical trees for its potential. It is an outstanding example of a species which is highly efficient in restoring soil productivity and simultaneously provide fodder, firewood and other products to meet the basic needs in the rural households like medicines, pesticides, mosquito repellents, fertilizers, diabetic food, soaps, lubricants, gums, agricultural implements, tooth paste, tooth brush sticks and even contraceptives.

Neem is a moderate to large tree with a stout and rather short stem, generally branching early and forming a large, fairly dense and rounded crown of bright green foliage. Normally it attains a height of 12-15 m, rarely upto 25 m, and a girth of 1.8-2.5 m. Although usually described as evergreen it becomes deciduous in drier areas. Neem tree has wide climatic adaptability.

Neem is mostly planted in blocks or as single plants in most of the States of India,

Table 1

Equations for estimating OB Timber Volume

Eqn. No.	Regression	R^2 (%)	df	Furnival index	Std. error of Estimate
1.	$TMOB = -0.073486 + 0.00002595\ D^2H$	99.4	9	0.0109545	0.00981153
2.	$TMOB = -0.11512 + 0.00001948\ D^2H + 0.0003026\ DH$	99.4	9	0.0114891	0.00962751
3.	$\text{Log}(TMOB) = -15.7902 + 1.52335\ \text{Log}(D^2H)$	98.5	9	0.0149298	0.0198318

* Presently at Conifers Research Centre, Shimla

Table 2

Volume Table Azadirachta indica

Timber Volume (Overbark) (m^3)
(TMOB) = -0.115120 + 0.00030260*D*H + 0.00001948*D*D*H

D.B.H.	Height (m)										
(cm)	10	11	12	13	14	15	16	17	18	19	20
20.0	.023	.037	.051	.065	.079	.093	.106	.120	.134	.148	.162
21.0	.034	.049	.064	.079	.094	.109	.124	.139	.154	.169	.184
22.0	.046	.062	.078	.094	.110	.126	.142	.158	.174	.191	.207
23.0	.058	.075	.092	.109	.127	.144	.161	.178	.196	.213	.230
24.0	.070	.088	.107	.125	.144	.162	.181	.199	.218	.236	.255
25.0	.082	.102	.122	.141	.161	.181	.201	.220	.240	.260	.280
26.0	.095	.116	.137	.158	.179	.200	.221	.242	.264	.285	.306
27.0	.109	.131	.153	.176	.198	.220	.243	.265	.288	.310	.332
28.0	.122	.146	.170	.194	.217	.241	.265	.289	.312	.336	.360
29.0	.136	.162	.187	.212	.237	.262	.287	.313	.338	.363	.388
30.0	.151	.178	.204	.231	.257	.284	.311	.337	.364	.390	.417
31.0	.166	.194	.222	.250	.278	.306	.334	.363	.391	.419	.447
32.0	.181	.211	.240	.270	.300	.329	.359	.389	.418	.448	.477
33.0	.197	.228	.259	.290	.322	.353	.384	.415	.446	.478	.509
34.0	.213	.246	.279	.311	.344	.377	.410	.443	.475	.508	.541
35.0	.229	.264	.298	.333	.367	.402	.436	.471	.505	.540	.574
36.0	.246	.282	.319	.355	.391	.427	.463	.499	.535	.572	.608
37.0	.264	.301	.339	.377	.415	.453	.491	.529	.566	.604	.642
38.0	.281	.321	.360	.400	.440	.479	.519	.559	.598	.638	.677
39.0	.299	.341	.382	.423	.465	.506	.548	.589	.631	.672	.713
40.0	.318	.361	.404	.447	.491	.534	.577	.621	.664	.707	.750
41.0	.336	.382	.427	.472	.517	.562	.607	.652	.698	.743	.788
42.0	.356	.403	.450	.497	.544	.591	.638	.685	.732	.779	.826
43.0	.375	.424	.473	.522	.571	.620	.669	.718	.767	.816	.865
44.0	.395	.446	.497	.548	.599	.650	.701	.752	.803	.854	.905
45.0	.416	.469	.522	.575	.628	.681	.734	.787	.840	.893	.946
46.0	.436	.491	.547	.602	.657	.712	.767	.822	.877	.933	.988
47.0	.457	.515	.572	.629	.686	.744	.801	.858	.915	.973	1.030
48.0	.479	.538	.598	.657	.717	.776	.835	.895	.954	1.014	1.073
49.0	.501	.562	.624	.686	.747	.809	.870	.932	.994	1.055	1.117
50.0	.523	.587	.651	.751	.778	.842	.906	.970	1.034	1.098	1.161

Note : Figures enclosed within the lines are within the range of observed data.

specially in northern and western parts. It is also suitable for afforestation of wastelands, and planting under agroforestry and silvi-pastoral systems. Neem is a successful species in Nigeria as shelterbelts to protect soil and crops against hot dry winds. In Northern Nigeria, Neem interplanted with groundnuts, beans, and millets in farmlands showed markedly superior growth.

The annuals rings on Neem are sometimes not quite distinct. Naturally grown Neem trees of ten years age measured in Bellary District of Karnataka State, gave an average height of 6.58 metres and girth of 68.1 cm. The rate of growth of Neem in plantations varies depending upon the quality of the soil on which it is grown. A recent study in Western Rajasthan showed that the growth is fast in the first ten years and then it slows down (Tewari *et al.*, 1996).

Growth studies on this important tree are found wanting. Actually literature does not give even local volume tables of this species for the Indian sub-continent. Gujarat State Forest Department has taken up large scale plantations of Neem at different places. It was deemed worthwhile to prepare a volume table of Neem based on data from these plantations which may suitable for the arid region of Western India.

Methodology

These tables are based on the data collected from 25 trees felled from the surrounds of five sample plots of Neem laid out in Gandhinagar Division of Gujarat State. The volume of trees was calculated overbark and underbark upto 5 cm diameter overbark. The dbh and height ranged from 7 cm to 36 cm and 6 m to 16 m respectively. Regression method was used for preparation of the volume tables. Different models were tried. In each model diameter at breast height (D) is taken in cm, height (H) in metres and timber and total wood volume overbark (TMOB and TWOB) and underbark (TMUB and TWUB) in cubic metres. Coefficient of correlation (R^2), Standard error of estimate (SEE) and Furnival Index (Furnival, 1961), wherever applicable, were used to select the best regression equation.

Results and Discussion

For the purpose of computing volume tables, different equations for volume (of timber, total wood etc.) involving diameter at breast height (D) and total height (H) of the trees were developed. The equation which showed the minimum Furnival index and/or standard error of estimate and maximum R^2 was then chosen in each case

Table 3

Equations for estimating UB Timber Volume

Eqn. No.	Regression	R^2 (%)	df	Furnival index	Std. error of Estimate
4.	$TMUB = -0.061054 + 0.00002122\ D^2H$	99.4	9	0.00894427	0.00808743
5.	$TMUB = -0.12078 + 0.00001193\ D^2H + 0.0004341\ DH$	99.5	9	0.00911043	0.00761895
6.	$Log(TMUB) = -16.3519 + 1.56116\ Log(D^2H)$	98.2	9	0.0137901 '	0.0190186

Table 4

Volume Table Azadirachta indica

Timber Volume (Underbark) (m^3)

(TMUB) = -0.120780 + 0.00043410*D*H + 0.00001193*D*D*H

D.B.H.	Height (m)										
(cm)	10	11	12	13	14	15	16	17	18	19	20
20.0	.014	.027	.041	0.54	.068	.081	.094	.108	.121	.135	.148
21.0	.023	.037	.052	.066	.081	.095	.109	.124	.138	.152	.167
22.0	.032	.048	.063	.078	.094	.109	.124	.140	.155	.170	.186
23.0	.042	.058	.075	.091	.107	.124	.140	.156	.173	.189	.205
24.0	.052	.069	.087	.104	.121	.139	.156	.173	.190	.208	.225
25.0	.062	.081	.099	.117	.136	.154	.172	.190	.209	.227	.245
26.0	.073	.092	.111	.131	.150	.169	.189	.208	.228	.247	.266
27.0	.083	.104	.124	.145	.165	.185	.206	.226	.247	.267	.288
28.0	.094	.116	.137	.159	.180	.202	.223	.245	.266	.288	.309
29.0	.105	.128	.151	.173	.196	.219	.241	.264	.286	.309	.332
30.0	.117	.141	.164	.188	.212	.236	.259	.283	.307	.331	.354
31.0	.128	.153	.178	.203	.228	.253	.278	.303	.328	.353	.378
32.0	.140	.166	.193	.219	.245	.271	.297	.323	.349	.375	.401
33.0	.152	.180	.207	.234	.262	.289	.316	.344	.371	.398	.426
34.0	.165	.193	.222	.250	.279	.307	.336	.365	.393	.422	.450
35.0	.177	.207	.237	.267	.297	.326	.356	.386	.416	.446	.475
36.0	.190	.221	.252	.283	.314	.346	.377	.408	.439	.470	.501
37.0	.203	.236	.268	.300	.333	.365	.398	.430	.462	.495	.527
38.0	.216	.250	.284	.318	.351	.385	.419	.453	.486	.520	.554
39.0	.230	.265	.300	.335	.370	.405	.440	.476	.511	.546	.581
40.0	.244	.280	.317	.353	.390	.426	.462	.499	.535	.572	.608
41.0	.258	.296	.333	.371	.409	.447	.485	.523	.561	.598	.636
42.0	.272	.311	.351	.390	.429	.468	.508	.547	.586	.625	.665
43.0	.286	.327	.368	.409	.449	.490	.531	.572	.612	.653	.694
44.0	.301	.343	.386	.428	.470	.512	.554	.597	.639	.681	.723
45.0	.316	.360	.404	.447	.491	.535	.578	.622	.666	.709	.753
46.0	.331	.377	.422	.467	.512	.557	.603	.648	.693	.738	.783
47.0	.347	.394	.440	.487	.534	.581	.627	.674	.721	.768	.814
48.0	.362	.411	.459	.507	.556	.604	.652	.701	.749	.797	.846
49.0	.378	.428	.478	.528	.578	.628	.678	.728	.778	.828	.878
50.0	.395	.446	.498	.549	.601	.652	.704	.755	.807	.858	.910

Note: Figures enclosed within the lines are within the range of observed data.

for computing volume tables.

Overbark timber volume : Out of the 25 trees felled, only 10 had timber (with overbark diameter >20 cm). Measurements of these sections were used for estimating timber volumes. The three equations involving both D and H generated for estimating the overbark timber volume are given in Table 1.

Among these three equations, the third one has minimum R^2 value and maximum Furnival index and maximum standard error of estimate (SEE). Hence this equation is deemed least desirable for volume computation. The first and second equations have maximum but similar R^2. Their Furnival indices are very similar too. But equation number 2 has the minimum SEE. Hence this equation was chosen for volume estimation. The overbark timber volume of Neem computed on the basis of this equation for intervals of 1 cm in dbh class and 1 m in height class are tabulated in Table 2.

Underbark timber volume : The three equations involving both D and H generated for estimating the underbark timber volume are given in Table 3.

Among these three equations, the equation no. 5 has minimum SEE and maximum R^2. Its Furnival index is very close to the minimum value obtained for equation 4. Hence equation 5 was chosen for volume estimation. The underbark timber volume of Neem computed on the basis of this equation for intervals of 1 cm in dbh class and 1 m in height class are tabulated in Table 4.

Overbark total wood volume : The total wood volume was estimated for the 25 felled trees by combining the timber volumes and small wood volumes. The three equations involving both D and H generated for estimating the overbark total wood volume are given in Table 5.

Among these three, equation No. 8 has the minimum standard error of estimate. Equations 7 and 8 have maximum but same R^2 value and almost similar Furnival indices. Hence equation No. 8 was selected for computation of total wood volume (overbark). The overbark total wood volume of Neem computed on the basis of this equation for intervals of 1 cm in dbh class and 1 m in height class are tabulated in Table 6.

Underbark total wood volume : The three equations involving both D and H generated for estimating the overbark total wood volume are given in Table 7.

Among these three, equation No. 11

Table 5

Equations for estimating OB Total Wood Volume

Eqn. No.	Regression	R^2 (%)	df	Furnival index	Std. error of Estimate
7.	$TWOB = -0.008415 + 0.00004429\ D^2H$	99.8	24	0.0100000	0.00948989
8.	$TWOB = -0.009886 + 0.00001838\ DH + 0.00004381 D^2H$	99.8	24	0.0101130	0.00947894
9.	$Log(TWOB) = -10.8990 + 1.09369\ Log(D^2H)$	99.3	24	0.0119725	0.0176913

Table 6

Total wood Azadirachta indica

Total Wood (Overbark) (m^3)

$$(TWOB) = -0.009886 + 0.00001838*D*H + 0.00004381*D*D*H$$

D.B.H. (cm)	Height (m) 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
10.0	.018	.022	.027	.031	.036	.040	.045	.049	.054	.059	.063	.068	.072	.077	.081
11.0	.023	.029	.034	.040	.045	.051	.056	.062	.067	.073	.078	.084	.089	.095	.100
12.0	.029	.036	.042	.049	.055	.062	.068	.075	.082	.088	.095	.101	.108	.114	.121
13.0	.036	.044	.051	.059	.067	.074	.082	.089	.097	.105	.112	.120	.128	.135	.143
14.0	.043	.052	.061	.070	.079	.087	.096	.105	.114	.123	.132	.140	.149	.158	.167
15.0	.051	.061	.071	.081	.091	.102	.112	.122	.132	.142	.152	.162	.173	.183	.193
16.0	.059	.071	.082	.094	.105	.117	.128	.140	.151	.163	.174	.186	.197	.209	.220
17.0	.068	.081	.094	.107	.120	.133	.146	.159	.172	.185	.198	.211	.224	.237	.250
18.0	.077	.092	.106	.121	.135	.150	.164	.179	.193	.208	.223	.237	.252	.266	.281
19.0	.087	.103	.119	.136	.152	.168	.184	.200	.216	.233	.249	.265	.281	.297	.313
20.0	.097	.115	.133	.151	.169	.187	.205	.223	.241	.258	.276	.294	.312	.330	.348
21.0	.108	.128	.148	.167	.187	.207	.227	.246	.266	.286	.305	.325	.345	.365	.384
22.0	.120	.141	.163	.185	.206	.228	.249	.271	.293	.314	.336	.357	.379	.401	.422
23.0	.132	.155	.179	.202	.226	.250	.273	.297	.320	.344	.368	.391	.415	.438	.462
24.0	.144	.170	.196	.221	.247	.273	.298	.324	.350	.375	.401	.427	.452	.478	.504
25.0	.157	.185	.213	.241	.269	.296	.324	.352	.380	.408	.436	.463	.491	.519	.547
26.0	.171	.201	.231	.261	.291	.321	.351	.381	.411	.442	.472	.502	.532	.562	.592
27.0	.185	.217	.250	.282	.314	.347	.379	.412	.444	.477	.509	.541	.574	.606	.639
28.0	.199	.234	.269	.304	.339	.374	.408	.443	.478	.513	.548	.583	.618	.652	.687
29.0	.214	.252	.289	.327	.364	.401	.439	.476	.513	.551	.588	.626	.663	.700	.738
30.0	.230	.270	.310	.350	.390	.430	.470	.510	.550	.590	.630	.670	.710	.750	.790
31.0	.246	.289	.331	.374	.417	.459	.502	.545	.588	.630	.673	.716	.758	.801	.844
32.0	.263	.308	.354	.399	.445	.490	.536	.581	.626	.672	.717	.763	.808	.854	.899
33.0	.280	.328	.377	.425	.473	.522	.570	.618	.667	.715	.763	.811	.860	.908	.956
34.0	.298	.349	.400	.452	.503	.554	.605	.657	.708	.759	.810	.862	.913	.964	1.015
35.0	.316	.370	.425	.479	.533	.588	.642	.696	.750	.805	.859	.913	.968	1.022	1.076
36.0	.335	.392	.450	.507	.565	.622	.679	.737	.794	.852	.909	.967	1.024	1.081	1.139
37.0	.354	.415	.475	.536	.597	.657	.718	.779	.839	.900	.961	1.021	1.082	1.143	1.203
38.0	.374	.438	.502	.566	.630	.694	.758	.822	.886	.950	1.013	1.077	1.141	1.205	1.269
39.0	.394	.462	.529	.596	.664	.731	.798	.866	.933	1.000	1.068	1.135	1.202	1.270	1.337
40.0	.415	.486	.557	.628	.698	.769	.840	.911	.982	1.053	1.123	1.194	1.265	1.336	1.407
41.0	.437	.511	.585	.660	.734	.808	.883	.957	1.032	1.106	1.180	1.255	1.329	1.404	1.478
42.0	.458	.536	.615	.693	.771	.849	.927	1.005	1.083	1.161	1.239	1.317	1.395	1.473	1.551
43.0	.481	.563	.644	.726	.808	.890	.972	1.053	1.135	1.217	1.299	1.381	1.462	1.544	1.626
44.0	.504	.589	.675	.761	.846	.932	1.018	1.103	1.189	1.274	1.360	1.446	1.531	1.617	1.703
45.0	.527	.617	.706	.796	.886	.975	1.065	1.154	1.244	1.333	1.423	1.512	1.602	1.691	1.781
46.0	.551	.645	.738	.832	.926	1.019	1.113	1.206	1.300	1.393	1.487	1.580	1.674	1.768	1.861
47.0	.576	.674	.771	.869	.967	1.064	1.162	1.259	1.357	1.455	1.552	1.650	1.748	1.845	1.943
48.0	.601	.703	.805	.906	1.008	1.110	1.212	1.314	1.416	1.517	1.619	1.721	1.823	1.925	2.027
49.0	.627	.733	.839	.945	1.051	1.157	1.263	1.369	1.475	1.581	1.688	1.794	1.900	2.006	2.112
50.0	.653	.763	.874	.984	1.095	1.205	1.315	1.426	1.536	1.647	1.757	1.868	1.978	2.089	2.199

Note: Figures enclosed within the lines are within the range of observed data.

has the minimum standard error of estimate. Equations 10 and 11 have maximum but same R^2 value and almost similar Furnival indices. Hence equation No. 11 was selected for computation of total wood volume (underbark). The underbark total wood volume of Neem computed on the basis of this equation for intervals of 1 cm in dbh class and 1 m in height class are tabulated in Table 8.

The equations involving both D and H chosen for computing various volumes for Neem are listed below (TMOB = overbark timber volume, TMUB = underbark timber volume, TWOB = overbark total wood volume, TWUB = underbark total wood volume, D = diameter at breast height, H = Tree height).

$$TMOB = -0115120 + 0.00030260\ DH + 0.00001948\ D^2H$$

$$TMUB = -0.120780 + 0.00043410\ DH + 0.00001193\ D^2H$$

$$TWOB = -0.009886 + 0.00001838\ DH + 0.00004381\ D^2H$$

$$TWUB = -0.005644 - 0.00005481\ DH + 0.00035960\ D^2H$$

Regression equations with only (D) as the independent variable : The above equations contain both dbh and tree height as independent variables. In case of large enumerations it is not often possible to measure heights of every individual tree. Different relations between volume of tree and dbh were studied. Three equations were fitted to each volume data set. The equations fitted for overbark timber volume (TMOB), underbark timber volume (TMUB), overbark total wood volume (TWOB) and underbark total wood volume (TWUB) are given in Table 9.

In this case also the equations were chosen according to the minimum SEE, minimum Furnival index and maximum R^2 value as in the foregoing cases. The equations suggested for TMOB, TMUB, TWOB and TWUB are equation numbers 13, 16, 19 and 22 respectively. The volumes computed according to these equations are given in Tables 10 and 11.

The equations involving only D chosen for computing various volumes for Neem are listed below (TMOB = overbark timber volume, TMUB = underbark timber volume, TWOB = overbark total wood volume, TWUB = underbark total wood volume, D = diameter at breast height).

$$TMOB = 0.33140 - 0.035780\ D + 0.00108720\ D^2$$
$$TMUB = 0.24180 - 0.027156\ D + 0.00085130\ D^2$$
$$TWOB = 0.07033 - 0.013865\ D + 0.00098532\ D^2$$
$$TWUB = 0.05973 - 0.011755\ D + 0.00079016\ D^2$$

Table 7

Equations for estimating OB Total Wood Volume

Eqn. No.	Regression	R^2 (%)	df	Furnival index	Std. error of Estimate
10.	$TWUB = -0.010031 + 0.00003453\ D^2H$	99.8	24	0.00812939	0.00780831
11.	$TWUB = -0.005644 - 0.00005481\ DH + 0.0003596\ D^2H$	99.8	24	0.00820199	0.00768906
12.	$Log(TWUB) = -11.4951 + 1.12988\ Log(D^2H)$	99.2	24	0.00977118	0.0158332

Table 6

Volume Table Azadirachta Indica

Total Wood (Underbark) (m^3)

(TWUB) = - 0.005644 - 0.00005481*D*H + 0.00003596*D*D*H

D.B.H.	Height (m)														
(cm)	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
10.0	.013	.016	.019	.022	.025	.028	.031	.034	.037	.040	0.43	.046	.049	.052	.055
11.0	.017	.021	.024	.028	.032	.036	.039	.043	.047	.051	.054	.058	.062	.066	.069
12.0	.021	.026	.031	.035	.040	.044	.049	.053	.058	.062	.067	.071	.076	.080	.085
13.0	.027	.032	.037	.043	.048	.053	.059	.064	.069	.075	.080	.086	.091	.096	.102
14.0	.032	.038	.045	.051	.057	.063	.070	.076	.082	.089	.095	.101	.107	.114	.120
15.0	.038	.045	.053	.060	.067	.074	.082	.089	.096	.103	.111	.118	.125	.132	.140
16.0	.044	.053	.061	.069	.078	.086	.094	.103	.111	.119	.128	.136	.144	.153	.161
17.0	.051	.061	.070	.080	.089	.098	.108	.117	.127	.136	.146	.155	.165	.174	.184
18.0	.058	.069	.080	.090	.101	.112	.122	.133	.144	.154	.165	.176	.186	.197	.208
19.0	.066	.078	.090	.102	.114	.126	.138	.150	.162	.173	.185	.197	.209	.221	.233
20.0	.074	.087	.101	.114	.127	.141	.154	.167	.180	.194	.207	.220	.234	.247	.260
21.0	.083	.097	.112	.127	.141	.156	.171	.186	.200	.215	.230	.244	.259	.274	.289
22.0	.092	.108	.124	.140	.156	.173	.189	.205	.221	.237	.254	.270	.286	.302	.318
23.0	.101	.119	.136	.154	.172	.190	.208	.225	.243	.261	.279	.296	.314	.332	.350
24.0	.111	.130	.150	.169	.188	.208	.227	.247	.266	.285	.305	.324	.344	.363	.382
25.0	.121	.142	.163	.184	.205	.227	.248	.269	.290	.311	.332	.353	.374	.395	.416
26.0	.132	.155	.177	.200	.223	.246	.269	.292	.315	.338	.360	.383	.406	.429	.452
27.0	.143	.168	.192	.217	.242	.266	.291	.316	.341	.365	.390	.415	.440	.464	.489
28.0	.154	.181	.208	.234	.261	.288	.314	.341	.368	.394	.421	.448	.474	.501	.528
29.0	.166	.195	.224	.252	.281	.310	.338	.367	.395	.424	.453	.481	.510	.539	.567
30.0	.179	.209	.240	.271	.302	.332	.363	.394	.424	.455	.486	.517	.547	.578	.609
31.0	.192	.224	.257	.290	.323	.356	.389	.422	.454	.487	.520	.553	.586	.619	.652
32.0	.205	.240	.275	.310	.345	.380	.415	.450	.485	.520	.555	.591	.626	.661	.696
33.0	.218	.256	.293	.331	.368	.405	.443	.480	.517	.555	.592	.629	.667	.704	.741
34.0	.233	.272	.312	.352	.391	.431	.471	.511	.550	.590	.630	.669	.709	.749	.788
35.0	.247	.289	.331	.374	.416	.458	.500	.542	.584	.626	.668	.711	.753	.795	.837
36.0	.262	.307	.351	.396	.441	.485	.530	.575	.619	.664	.708	.753	.798	.842	.887
37.0	.278	.325	.372	.419	.466	.514	.561	.608	.655	.702	.750	.797	.844	.891	.938
38.0	.293	.343	.393	.443	.493	.543	.592	.642	.692	.742	.792	.842	.892	.941	.991
39.0	.310	.362	.415	.467	.520	.572	.625	.678	.730	.783	.835	.888	.940	.993	1.046
40.0	.326	.382	.437	.492	.548	.603	.658	.714	.769	.825	.880	.935	.991	1.046	1.101
41.0	.344	.402	.460	.518	.576	.635	.693	.751	.809	.867	.926	.984	1.042	1.100	1.158
42.0	.361	.422	.483	.545	.606	.667	.728	.789	.850	.911	.972	1.034	1.095	1.156	1.217
43.0	.379	.443	.507	.572	.636	.700	.764	.828	.892	.956	1.020	1.085	1.149	1.213	1.277
44.0	.398	.465	.532	.599	.666	.734	.801	.868	.935	1.002	1.070	1.137	1.204	1.271	1.338
45.0	.416	.487	.557	.628	.698	.768	.839	.909	.979	1.050	1.120	1.190	1.261	1.331	1.401
46.0	.436	.509	.583	.656	.730	.804	.877	.951	1.024	1.098	1.171	1.245	1.319	1.392	1.466
47.0	.456	.532	.609	.686	.763	.840	.917	.994	1.070	1.147	1.224	1.301	1.378	1.455	1.532
48.0	.476	.556	.636	.716	.797	.877	.957	1.037	1.117	1.198	1.278	1.358	1.438	1.519	1.599
49.0	.496	.580	.664	.747	.831	.915	.998	1.082	1.166	1.249	1.333	1.416	1.500	1.584	1.667
50.0	.517	.604	.692	.779	.866	.953	1.040	1.127	1.215	1.302	1.389	1.476	1.563	1.650	1.738

Note: Figure enclosed within the lines are within the range of observed data.

Table 9

Equations fitted for TMOB, TMUB, TWOB and TWUB

Eqn. No.	Regression	R^2 (%)	df	Furnival index	Std. error of Estimate
13	$TMOB=0.3314-0.03578D+0.0010872D^2$	99.0	9	0.0155885	0.0130428
14	$\sqrt{TMOB}=-0.33914+0.027672D$	98.1	9	0.0172370	0.0157038
15	$TMOB=-0.14380+0.00043829D^2$	97.3	9	0.0236643	0.0211200
16	$TMUB=0.2418-0.027156D+0.0008513D^2$	98.9	9	0.0129228	0.0108160
17	$\sqrt{TMUB}=-0.31552+0.025282D$	98.2	9	0.0138319	0.0122777
18	$TMUB=-0.11884+0.00035873D^2$	97.5	9	0.0184391	0.0166126
19	$TWOB=0.07033-0.013865D+0.00098532D^2$	99.3	24	0.0216585	0.0203194
20	$\sqrt{TWOB}=-0.12306+0.0284637D$	99.0	24	0.0163423	0.0232901
21	$TWOB=-0.052446+0.00066236D^2$	98.5	24	0.0298547	0.0286503
22	$TWUB=0.05973-0.011755D+0.00079016D^2$	99.4	24	0.0154773	0.0145230
23	$\sqrt{TWUB}=-0.11941+0.0253778D$	99.0	24	0.0120928	0.0173949
24	$TWUB=-0.044359+0.00051635D^2$	98.5	24	0.0234057	0.0224532

Table 10

Timber Volumes computed according to equations suggested

D.B.H. (cm)	Timber wood volume in (m^3)	
	Timber wood volume (Overbark)	Timber wood volume (Underbark)
	(TMOB) = 0.3314 - 0.03578 D + 0.0010878 D^2	(TMUB)=0.2418 - 0.027156 D + 0.0008513 D^2
1	2	3
20	0.051	0.039
21	0.059	0.047
22	0.070	0.056
23	0.084	0.068
24	0.099	0.080
25	0.116	0.095
26	0.136	0.111
27	0.158	0.129
28	0.182	0.149

Contd...

1	2	3
29	0.208	0.170
30	0.236	0.193
31	0.267	0.218
32	0.300	0.245
33	0.335	0.273
34	0.372	0.303
35	0.411	0.334
36	0.452	0.367
37	0.496	0.402
38	0.542	0.439
39	0.590	0.478
40	0.640	0.518
41	0.692	0.559
42	0.746	0.603
43	0.803	0.648
44	0.862	0.695
45	0.923	0.744
46	0.986	0.794
47	1.051	0.846
48	1.119	0.900
49	1.189	0.955
50	1.260	1.012

Table 11

Total Wood Volumes computed according to equations suggested

D.B.H. (cm)	Total wood volume in (m^3)	
	Total wood volume (Overbark)	Total wood volume (Underbark)
	(TWOB) = 0.07033 - 0.013865 D + 0.00098532 D^2	(TWUB) = 0.05973 - 0.011755 D + 0.00079016 D^2
1	2	3
10	0.030	0.021
11	0.037	0.026
12	0.046	0.032
13	0.057	0.040
14	0.069	0.050
15	0.084	0.061
16	0.101	0.074
17	0.119	0.088
18	0.140	0.104
19	0.163	0.122
20	0.187	0.141
21	0.214	0.161
22	0.242	0.184
23	0.273	0.207
24	0.305	0.233
25	0.340	0.260
26	0.376	0.288

Contd...

1	2	3
27	0.414	0.318
28	0.455	0.350
29	0.497	0.383
30	0.541	0.418
31	0.587	0.455
32	0.636	0.493
33	0.686	0.532
34	0.738	0.573
35	0.792	0.616
36	0.848	0.661
37	0.906	0.707
38	0.966	0.754
39	1.028	0.803
40	1.092	0.854
41	1.158	0.906
42	1.226	0.960
43	1.296	1.015
44	1.368	1.072
45	1.442	1.131
46	1.517	1.191
47	1.595	1.253
48	1.675	1.316
49	1.757	1.381
50	1.840	1.447

Acknowledgements

The authors are thankful to Shri.R.N. Mishra, Director, Arid Forest Research Institute, Jodhpur for his encouragement and for providing facilities for preparation of volume tables of Neem. We are thankful to P.C.C.F., Gujarat for according permission for laying out permanent sample plots of Neem and felling of 25 sample trees. The co-operation of C.F. and D.C.F., Gandhinagar and their staff is gratefully acknowledged. Thanks are also due to S/Shri Shiv Lal, J.P. Dadhich, Prem Singh Sankla and Mahesh Pandit for helping in laying out sample plots and collecting volume data.

SUMMARY

In this article volume tables of Neem based on data collected by felling 25 sample trees from different plantations in Gandhinagar Division of Gujarat State are presented. Different models were tried. Equations having the best fit on the basis of minimum Furnival Index, minimum standard error of estimate and maximum correlation coefficient have been selected for volume calculations.

गुजरात क्षेत्र के लिए *अजेडिरेक्टा इण्डिका* की आयतन सारणियाँ

आर०सी० जैन, एस०पी० त्रिपाठी, महेन्द्र सिंह व वी०एस० किशन कुमार

सारांश

प्रस्तुत अभिपत्र में गुजरात राज्य के गांधीनगर वन मण्डल में लगे विभिन्न रोपवनों से 25 नमूना वृक्ष पातित करके उनसे एकत्र किए आंकडों के आधार पर नीम की आयतन सारणियाँ दी गई हैं। कई मॉडल आजमाकर देखे गए है। न्यूनतम फुर्नीवाल निर्देशांक पर सबसे अच्छी तरह ठीक बैठने वाले समीकरण, अनुमान की न्यूनतम मानक त्रुटि और अधिकतम सहसंबन्धित गुणांक आयतन आंकलन के लिए चुने गए हैं।

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TERMITE-AIDED MESOCARP REMOVAL OF TEAK (*TECTONA GRANDIS* L.F) FRUITS FOR ENHANCED GERMINATION AND COST-EFFECTIVE SEED HANDLING

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Introduction

Poor germination of (untreated) fruits of Teak (*Tectona grandis* L.f) is a problem in forest nurseries. A variety of pre-sowing treatments have been recommended to enhance germination. Weathering, a process of alternate wetting and drying (Tewari, 1992; Viswanath *et al.*, 1995), and pit burial for a few days (Koshi, 1993) are some of the effective methods suggested. Mesocarp removal also is known to improve germination considerably, for which motorised Teak seed treatment machines have been devised (Grewal *et al.*, 1993; Bagat and Phulari, 1995). However, such mechanical procedures are costly and cumbersome.

As early as 1941, Beeson had foreseen the possibility of using termites to prepare Teak fruits for early germination (Beeson, 1941). In Myanmar and Thailand, white-ant treatment by burying the fruits for about one year near a termite mound is regarded as a useful method to enhance germination (Tewari, 1992). But no serious effort has been made so far to look into the practicality and usefulness of using termites for seed treatment. This paper reports results of an experiment conducted to study the germination of Teak fruits, after removal of mesocarp using subterranean termites.

Materials and Methods

The experiment was conducted in the campus of Kerala Forest Research Institute (KFRI), Peechi, Thrissur District, Kerala State. The weather conditions prevailing during the study period (20 December 1996 to 3 February 1997) are presented in Figure 1.

Mature fruits were collected from Teak trees growing in KFRI campus during December 1996. The fruits were sun-dried for three days and the loose acresent calyx cover was removed by rubbing together the fruits inside a gunny bag. The fruits were then size-graded using a set of sieves of mesh sizes 18 mm, 15 mm, 12 mm, 9 mm and 6 mm. The fruits of only 15-18 mm class were used in the study. In all 562 fruits were available for this study.

The size-graded fruits were divided into two equal parts; one part was subjected to weathering by alternate wetting with water during the night and drying in sun during the day, for 13 days. Simultaneously, the second part was put in a heap on the ground in the nursery area. Dry plant twigs were put along with the seeds and the heap was kept slightly moist to attract subterranean termites.

Weight and volume of fruits before and after treatments were recorded using weight balance and measuring cylinder. Moisture of sample fruits was also determined following a method described by Willan (1985).

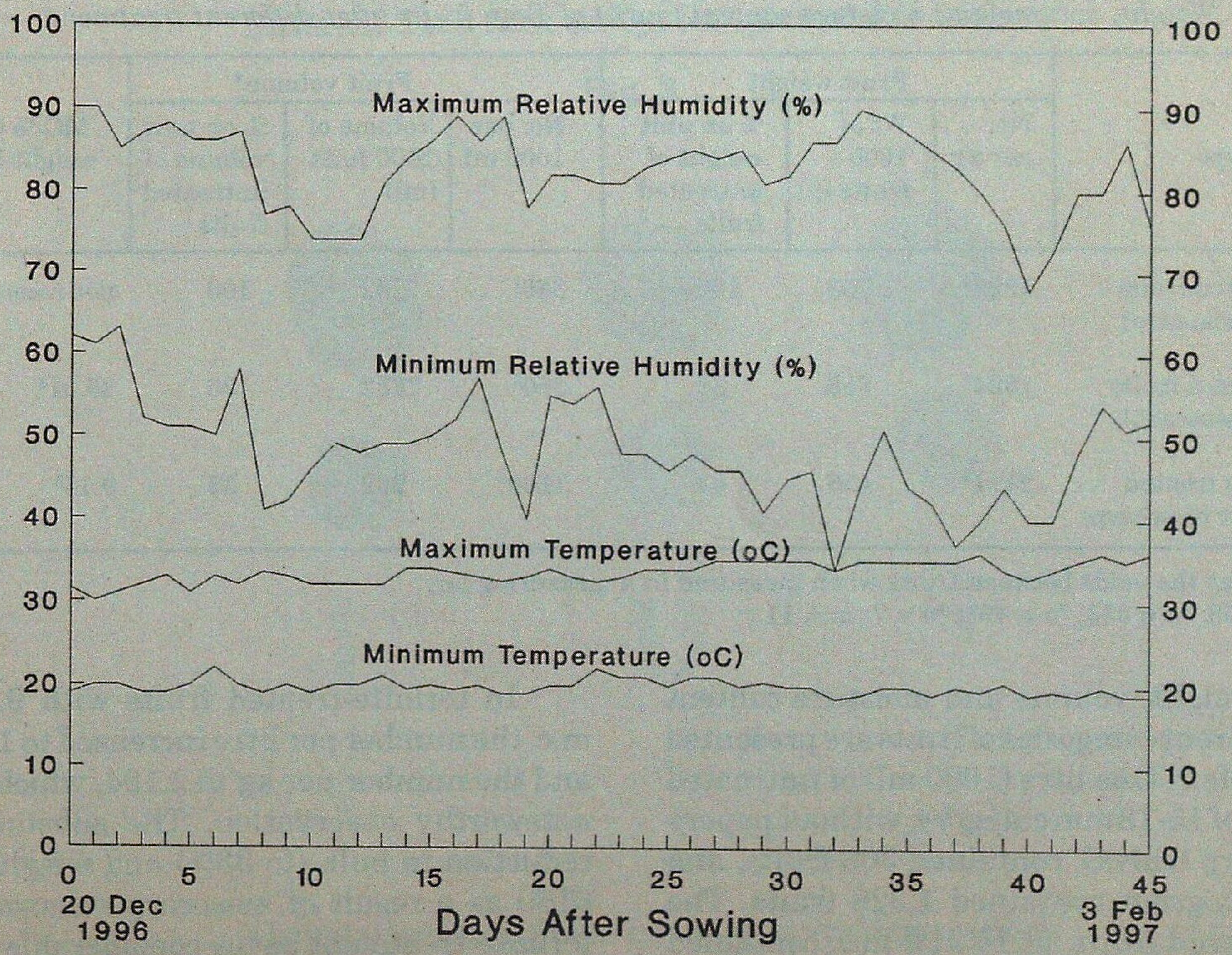
The seeds were sown in moistened vermiculite in plastic trays of 45 cm (length) x 35 cm (width) and 15 cm (height), which were provided with holes at the bottom to drain-off excess water. The vermiculite was watered sparingly to maintain moisture. The trays were kept under a shed provided with translucent 'silpauline' roof and open sides. Various pre-treatments and sowing methods tried in the study are described in Table 1. Different types of fruits used for sowing are shown in Figure 2, and the orientation of fruits in the germination medium are indicated in Figure 3.

Randomised Complete Block Design (RCBD), with four replicates per treatment, was followed for experimental layout; each replicate had 25 fruits per treatment. Observations on cumulative germination were recorded daily for 45 days. Data was subjected to analysis of variance, after arc-sin transformation of percentage values, to find out any significant difference between the treatments.

Results and Discussions

Seed weight, volume and moisture content :

Fig. 1



Weather conditions at Peechi during the study period

Table 1

Pre-sowing treatments of Teak fruits and fruit orientation in germination medium

Treatment code	Pre-treatment of fruits	Orientation of fruit in germination medium
WU	Maintaining the fruits moist during night and sun drying during day for 13 days (weathering)	Peduncle end up
WD	-do-	-do- down
WS	-do-	-do- side ways
TU	Subjecting the fruits to termite till the entire mesocarp is eaten	Peduncle end up
TD	-do-	-do- down
TS	-do-	-do- side ways

Table 2

Weight, volume and moisture content (mc%) of Teak fruits after different treatments

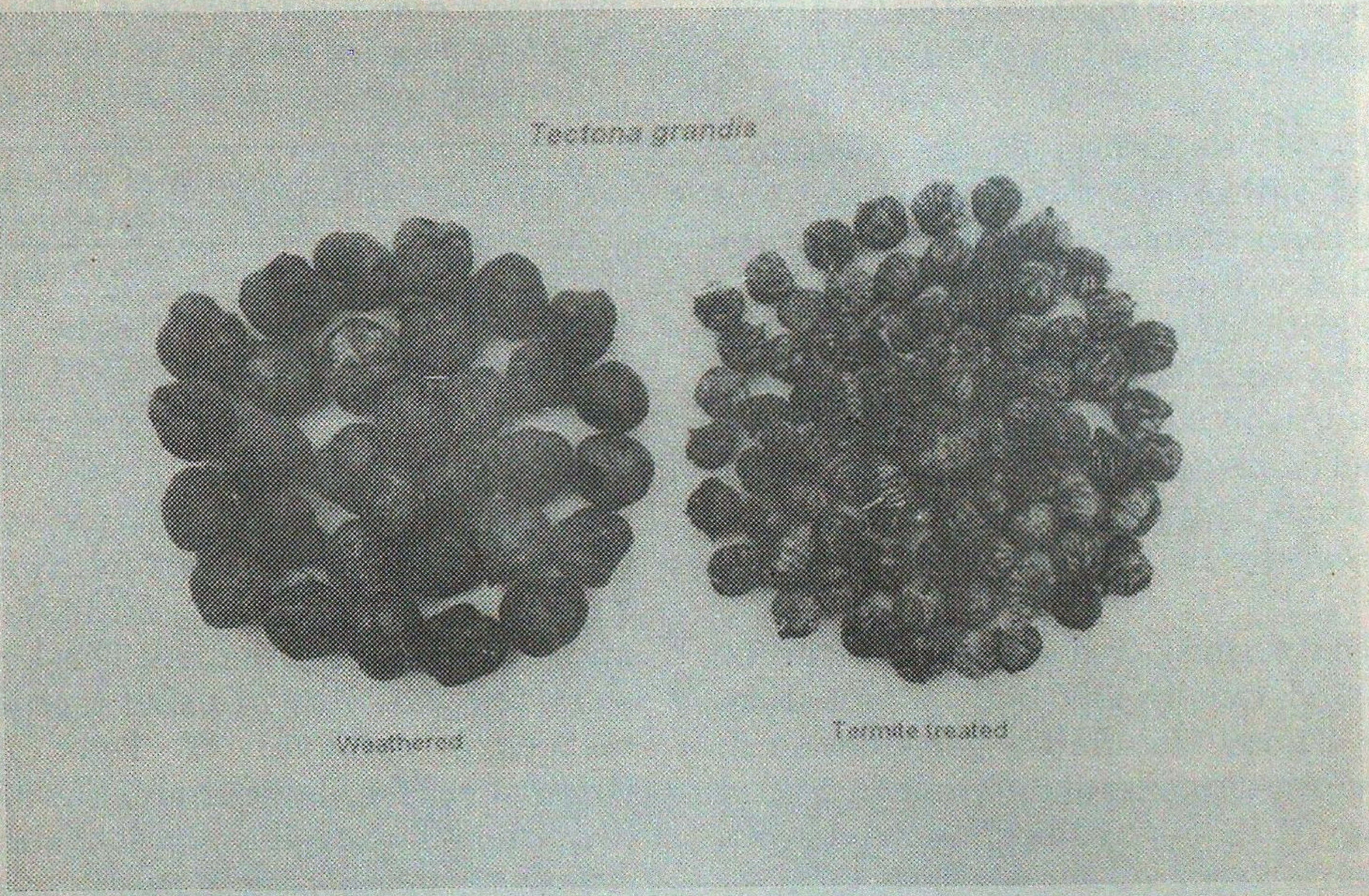
Fruit type	Fruit weight			Fruit volume*			MC % (fresh weight basis)
	No. per kg	Wt of 1000 fruits (g)	% on unit weight of untreated fruits	No. per 1000 ml	Volume of 1000 fuits (ml)	% on unit volume of untreated fruits	
Untreated fruits (with mesocarp)	1328[1]	753	100	366[1]	2732	100	not recorded
Weathered fruits (with mesocarp)	1524[2]	656	88	380[2]	2632	96	15.31[4]
Termite treated (without mesocarp)	2194[3]	456	61	1109[3]	902	33	9.15[5]

*Includes the voids between fruits when measured in a measuring jar.
[1]n = 1098; [2]n = 573; [3]n = 498; [4]n = 7; [5]n = 11

The weight, volume and moisture content of different categories of fruits are presented in Table 2. One litre (1000 ml) of untreated fruits of 15-18 mm category, without papery pericarp (calyx), contained 366 fruits, and one kilogram contained 1,328 fruits. The weathered fruits, at 15.31% m.c, contained 1,524 fruits per kg.

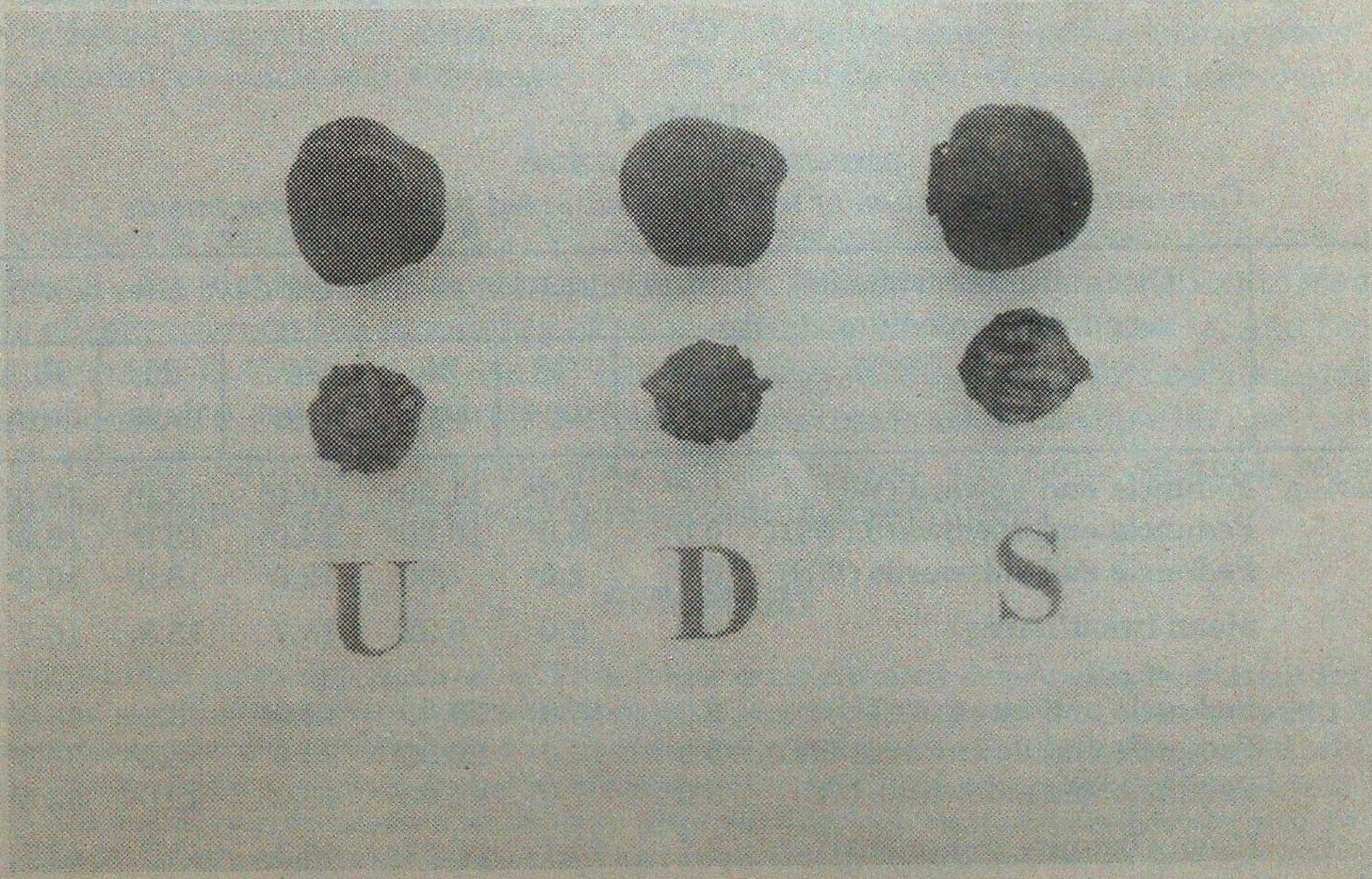
In termite-treated fruits with 9.15% m.c, the number per litre increased to 1,109 and the number per kg to 2,194, which is a noteworthy observation. The substantial reduction in bulk (to 33%) and weight (to 61%) as a result of mesocarp removal by termite treatment saves considerable cost of transportation. The output (by weight) in

Fig. 2



Different Teak fruit categories used for the study

Fig. 3



Orientation Teak fruits in the germination medium

U = Peduncle scar up, D = Peduncle scar down, S = Peduncle scar side ways

termite-treated fruits in this study (61%) agrees with that in mechanical method (60%) as reported by Bagat and Phulari (1995).

In termite treatment, the infestation started within two days of heaping and entire mesocarp of all fruits was eaten up by termites within 13 days, leaving behind fruits with stony endocarp (Fig. 2). The termites were identified as *Odontotermes guptai*. About 97% (by weight) of termites-treated fruits belonged to the size category of 9-12 mm. Only 3% of the fruits were in the lower category of 6-9 mm (Table 3).

The termite-treated fruits recorded early and remarkably high germination. Table 4 gives cumulative germination in different treatments at different days after sowing. At 15 days, none of the fruits with mesocarp germinated, whereas termite-treated fruits registered a mean germination of 2.7%. This trend continued till the 45th day when the germination was 17.3% for weathered seeds, and 45% for termite-treated seeds, clearly establishing the superiority of termite treated fruits for early and maximum germination. These results show the feasibility of using termites for mesocarp removal of Teak fruits. Orientation of seeds in germination medium had little effect on germination; although, collar deformities were higher in seedlings which emerged out of fruits sown with peduncle upwards or downwards. This aspect needs detailed investigation.

Table 3

Percentage conversion of fruits to different size categories when fruits in 15-18 mm size category were termite-treated (n = 498)

	Quality of fruits in each size category (%)		
	6-9 mm	9-12 mm	Total
Volume of fruits	3.6%	96.4%	100
Weight of fruits	2.6%	97.4%	100

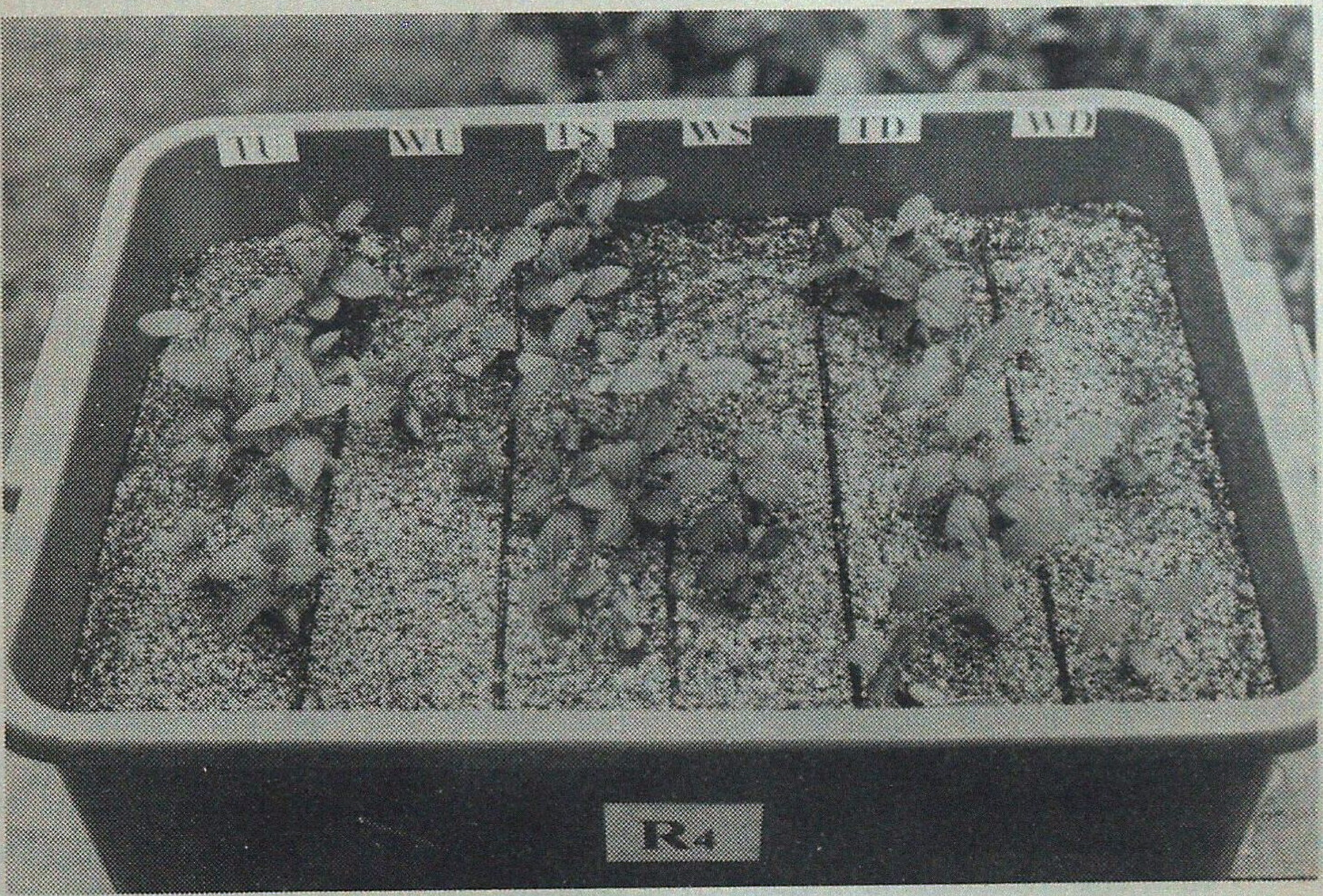
Table 4

Cumulative germination of teak fruits subjected to different treatments

Treatment	Orientation of fruits in germination medium	% germination at different days after sowing						
		15 days	20 days	25 days	30 days	35 days	40 days	45 days
Weathering	Peduncle end upward (WU)	0.0^{a}	1.0^{a}	11.00^{a}	16.0^{a}	18.0^{a}	19.0^{a}	20.0^{a}
	Peduncle end downward (WD)	0.0^{a}	6.0^{a}	10.00^{a}	13.0^{a}	15.0^{a}	16.0^{a}	17.0^{a}
	Peduncle end sidewards (WS)	0.0^{a}	2.0^{a}	7.00^{a}	12.0^{a}	13.0^{a}	15.0^{a}	15.0^{a}
	Mean (weathering)	0.0	3.0	9.32	13.7	15.3	16.7	17.3
Termite	Peduncle end upward (TU)	2.0^{a}	15.0^{a}	39.00^{b}	42.0^{b}	43.0^{bc}	43.0^{b}	45.0^{b}
	Peduncle end downwards (TD)	3.0^{a}	10.0^{a}	26.00^{b}	33.0^{b}	33.0^{b}	36.0^{b}	37.0^{b}
	Peduncle end sidewards (TS)	3.0^{a}	7.0^{a}	44.00^{b}	46.0^{b}	49.0^{b}	52.0^{b}	53.0^{b}
	Mean (Termite treatment)	2.7	10.7	36.32	40.3	41.7	43.7	45.0

Values in a column with same superscribed letter do not differ significantly at P=0.05.

Fig. 4



Germination of Teak fruits in different treatments in replicate 4 at 45 days after sowing

WU = Weathered, peduncle scar up
WD = Weathered, peduncle scar down
WS = Weathered, peduncle scar side ways
TU = Termite-treated, peduncle scar up
TD = Termite-treated, peduncle scar down
TS = Termite-treated, peduncle scar side ways

Acknowledgements

The author is grateful to Dr. R.V. Varma, Scientist-in-Charge, Division of Entomology, KFRI, Peechi, for identifying the species of termite and drawing my attention to Beeson's valuable observation on the possibility of using termites for fruit treatments, and Dr. J.K. Sharma, Scientist-in-Charge, Division of Plant Pathology, KFRI, Peechi, for useful suggestions for improvement of the manuscript. Mr. Subhash Kuriakose is acknowledged for photographs, S/Shri C. Herald John, K.R. George, M.C. Suresh Kumar and Smt. Ammini, rendered assistance in layout of the experiment and recording observations.

SUMMARY

Termite-aided mesocarp removal of Teak fruits is an efficient pre-sowing treatment for early and enhanced germination. For termite-treatment, fruits were left heaped in open-ground infested with subterranean termites (*Odontotermes guptai*) and supplemented with dry twigs and sufficient moisture. The termites ate away entire mesocarp within 13 days leaving behind fruits with stony endocarp. Cumulative germination at 20 days after sowing in termite-treated fruits was 10.7% as compared to 3% in alternate wetting and drying (weathering) treatment for 13 days; at 45 days the corresponding figures were 45% and 17.3% respectively. Mesocarp removal also reduced seed bulk and weight considerably; when mesocarp was removed, the seed volume reduced to 33% and the seed weight to 61%. Reduction in bulk and weight reduces the seed handling costs.

सागौन (*टैक्टोना ग्रांडिस* लि०वत्स) का अंकुरण बढ़ाने और लागत प्रभावी बीज उठाधरी के लिए दीमकों की सहायता से बीजों की मध्यभित्ति दूर करना

के०सी० चाको

सारांश

जल्दी और अधिक मात्रा में अंकुरण कराने के लिए सागौन के फलों से दीमकों की मदद लेकर उनकी मध्यभित्ति दूर कराना प्रभावकारी पूर्वोपवार है। दीमक उपचार के लिए फलों का चट्टा लगाकर उन्हें ऐसी खुली भूमि में छोड़ दिया गया जिनमें आन्तर्भौमि दीमकें (*ओडोण्टोटर्मिस गुप्ताई*) लगी हुई थी और उन पर सूखी टहनियों और पर्याप्त नमी डाल दी गई। इस दीमक ने पूरी मध्यभित्ति 13 दिन के अन्दर खा डाली और केवल गुठली वाले अन्तर्भित्ति युक्त फल बचे रह गए। बोने के 20 दिन उपरान्त संचयी अंकुरण एकान्तरित नम करना और सुखाना उपचार (ऋतुप्रभावन) 13 दिन तक करने के बाद हुए अंकुरण 3% की तुलना में 10.7% रहा। 45 दिनों के उपरान्त ये आंकडे क्रमशः 17.3% और 45% पाए गए। मध्यभित्ति दूर हो जाने से बीजों का फैलाव घटकर 33% और बीज भार घटकर 61% रह गया। फैलाव और भार में कमी होने से बीजों को इधर-उघर ले जाने की लागत में भी कमी होती है।

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ROLE OF VAMF IN ESTABLISHMENT OF *DENDROCALAMUS STRICTUS* IN FIELD

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Introduction

Bamboo is a boon for a developing country like India. On the one hand it serves as the back bone of the rural economy, on the other the length and strength of bamboo fibre makes it an ideal material for pulp and paper industry. About 325 paper mills spread over the country meet about 60% of their fibrous raw material from bamboo (Martin, 1996). Industrial demand for paper is rising but bamboo reserve is dwindling fast. In 1994, India imported newsprint, paper board, wood and pulp worth Rs. 1,854 crores and unfortunately this amount is likely to touch about Rs. 3000 crores by the turn of the century (Khoshoo, 1994). India can save its precious foreign exchange reserves by large scale planting of genetically superior stock of bamboo raised by hybridization and tissue culture techniques. However, the main hurdle in such effective programme is the low survival rate and poor growth of saplings on transplantation to field from greenhouse. This is probably due to soil related constraints of field like acidity, salinity, poor mineral content, water stress etc. However, there are several reports which illustrate successful application of VAMF technology in improving the survival and growth of plants under such adverse conditions (Call and Davies, 1988; Chandra and Kehri, 1995; Jamaluddin and Chandra, 1995; Sharma *et al.*, 1995) so thrust should be laid to test bamboo-VAMF, relationship in field conditions, which if proved successful can help in expanding bamboo cover in wastelands. Thus as per the need of the hour, in the present study the role played by VAM fungus in establishment of *D. strictus* saplings in field has been investigated.

Materials and Methods

The present study was carried out on tissue culture raised saplings of *Dendrocalamus strictus* procured from tissue culture pilot plant, Tata Energy Research Institute, New Delhi.

About 250 g of soil and sand mixture (1:1) containing about 1,250 spores of *Glomus macrocarpum* was used as inoculum. To inoculate *Dendrocalamus strictus* in pots the method of Amijee *et al.* (1986) was followed. In control plants about 250 g of soil and sand mixture (1:1) was added instead of inoculum.

The pots were maintained in green-house for 8 months after which they were transplanted in field. During transplantation, inoculated plants showed 68% root infection and uninoculated plants showed no infection. The percentage root

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infection was calculated by Grid Line intersect method (Giovanneti and Mosse, 1980) after clearing and staining the roots (Phillips and Hayman, 1970). Preinfected and uninfected *D. strictus* were planted in pits about 30 cm^3 in field. The soil of the respective pots was used for filling up these pits.

The tallest culm of a clump was taken as the height of the plant. Yield was measured as no. of culms per clump. The phosphate analysis was done from leaf tissue (Jackson, 1973).

Results

From Table 1 it is evident that when *D. strictus* was transplanted in field, the height of plants were similar in inoculated and uninoculated sets. After two months of transplantation the height of the inoculated set increased but remained constant in uninoculated set. From March onwards the height of uninoculated plants continued to decrease due to drying up of internode and by April height decreased by as much as 6.9 cm. Between April to May there was considerable improvement in height in both the sets.

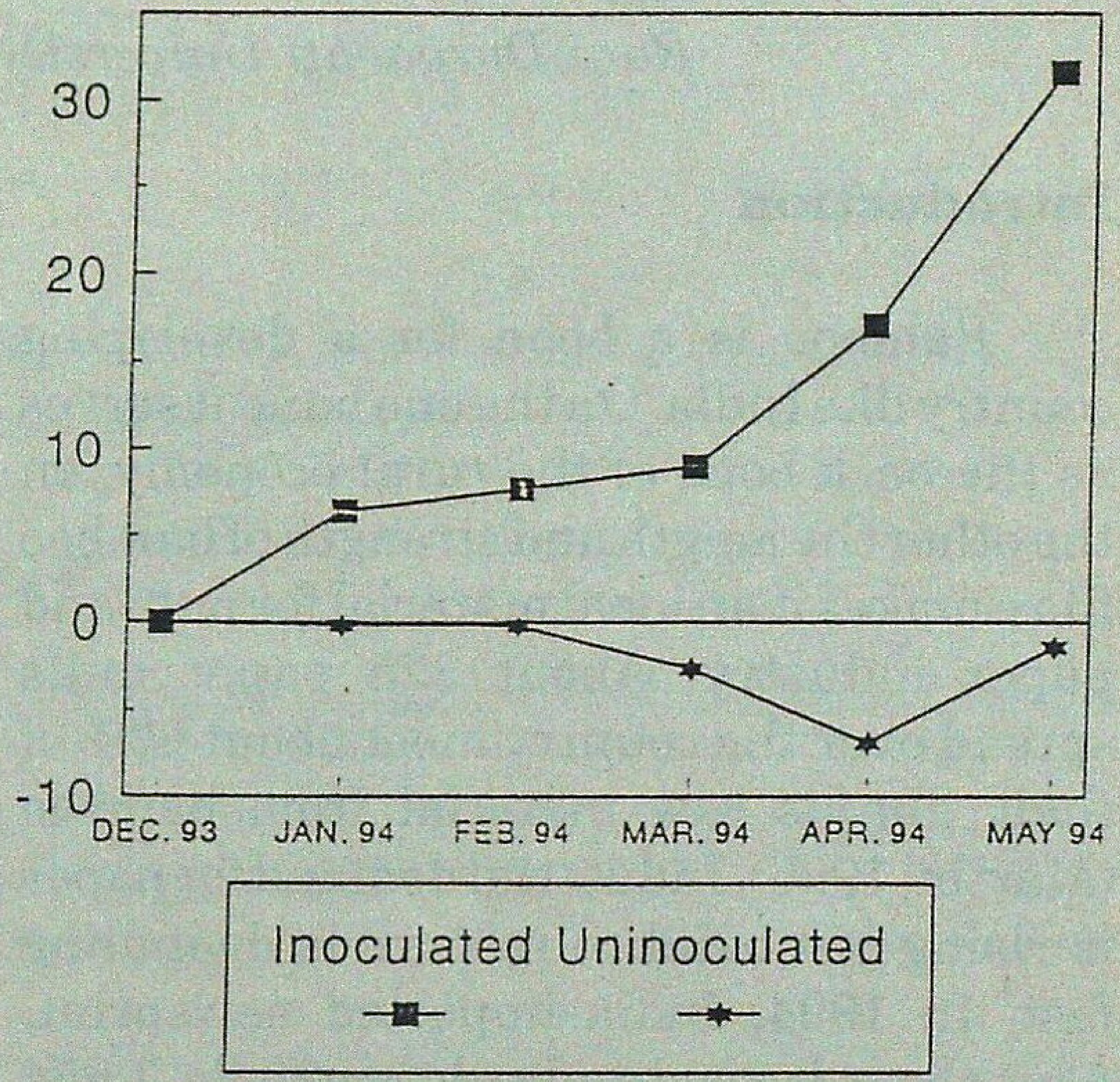
Table 1

Height of Dendrocalamus strictus

Months		Inoculated (cm)	Uninoculated (cm)
December	1993	42.3	43.2
January	1994	48.7	43.0
February	1994	50.0	43.0
March	1994	51.3	40.6
April	1994	59.4	36.3
May	1994	73.9	41.8

Fluctuation was noticed in the height of uninoculated plants. It initially remained constant for two months, then started decreasing and thereafter improved. But height of inoculated plants continued to rise throughout (Fig. 1).

Fig. 1



Change in height of *D. strictus* since transplantation

Initially, during transplantation, the number of culms per clump was same in inoculated and uninoculated plants but thereafter rate of culm production increased in inoculated set as compared to uninoculated set (Table 2).

Later on, throughout the study period the inoculated plants had greater height and higher culms/clump compared to uninoculated plants. After 5 months of transplantation 74.7% increase in height was noticed in inoculated plants while height of uninoculated plants decreased by 3.2 %. In the inoculated plants culm production increased by 208.5 % while in the uninoculated counterparts it increased only by 82.8 %.

Table 2

Culm production in Dendrocalamus strictus

Months		Inoculated (No.of Culms /Clump)	Uninoculated (No. of Culms/ Clump)
December	1993	7.00	7.0
January	1994	9.00	8.0
February	1994	11.70	9.1
March	1994	14.00	10.0
April	1994	17.75	10.6
May	1994	21.60	12.8

The phosphate content was found to be 0.16 % in inoculated plants and 0.12 % in uninoculated plants in March. Morphologically the inoculated plants appeared more fresh and green compared to uninoculated plants.

Discussion

From the present study it is evident that height of *D. strictus* remained constant in uninoculated set for some time and started decreasing thereafter till April. This is chiefly because of transplantation shock, while no such adverse affect of transplantation was observed in inoculated set, rather height of plants increased progressively throughout. Actually, when a plant is transplanted from pot kept in green-house to field, it experiences a sudden and harsh change in environment. In field, soil water status is generally low, the temperature is high, relative humidity of atmosphere is low, there is greater fluctuation of day and night temperatures, so the plant takes some time in acclimatization and during this process its growth rate is adversely affected. Transplantation process often injures tender roots which lowers the nutrient uptake capacity making the plant weak and susceptible to pathogenic attacks while inoculated plants are able to exploit the available resources in a better way with the aid of VAM fungi. The hyphae of VAM fungi extend into the soil and increase the absorptive zone (Bieleski, 1973) and uptake of phosphate, S, Fe, Cu, Zn from soil (Daft and Nicolson, 1966; Gray and Gerdemann, 1973; Buwalda *et al.*, 1983; Harley and Smith, 1983; Reena and Bagyaraj., 1990). Thus in the present case *Glomus macrocarpum* improved the mineral uptake of *D. strictus* and helped it to withstand transplantation shock. The inoculated plants appeared fresh and green as compared to uninoculated controls which appeared pale and dry. It is because the inoculated plants made prudential use of available water with the help of *G. macrocarpum* (Levy and Krikun, 1980; Lovato *et al.*, 1995; Sieverding, 1991).

Between April to May, growth rate improved in both the sets. This improvement may be attributed to some extent to flash of rain which occurred in April. Rain lowered the temperature, increased soil water status and relative humidity making the atmosphere congenial for growth of bamboo (Suri and Chauhan, 1984). This period also marked the end of leaf-fall season. With emergence of new leaves, the photosynthetic activity was resumed again actively and provided the necessary driving force for growth.

Phosphate content was found to be high in inoculated plants compared to uninoculated plants. This is in accordance with the work carried out by several workers (Bethlenfalvay and Yoder 1981; Gueye *et al.*, 1987; McArthur and Knowles, 1993). The overall growth of inoculated *D. strictus* was higher at all times compared to its

uninoculated counterparts. This increase in growth was the result of cumulative effect of increased phosphate and other mineral uptake, increased photosynthetic rate, improved water status brought by *Glomus macrocarpum* in *D. strictus*. In the present study, though survival rate of *D. strictus* was not affected adversely in absence of *Glomus macrocarpum* as observed in various cases (Johnson and Crews, 1979; Sundaram and Arangarasan, 1995; Fathima *et al*., 1995) but it did strengthen the view that VAM fungi plays a positive role in establishment of *D. strictus* in field and improve its growth rate.

Conclusion

From the present study it can be concluded that *Glomus macrocarpum* not only helped in successful establishment of tissue culture raised saplings of *D. strictus* in field by minimizing transplantation shock but also improved its growth rate over its uninoculated counterparts.

Acknowledgements

Authors are grateful to Prof. S.K. Hasija, Head, Deptt. of Biological Sciences, Rani Durgavati University, Jabalpur for providing Laboratory facility and also to Deptt. of Biotechnology, New Delhi for financial assistance.

SUMMARY

This paper describes the role of VAMF in establishment of *Dendrocalamus strictus* in field and improvement of its growth rate.

क्षेत्र में डैंड्रोकैलेमस स्ट्रिक्टस की स्थापना में वैम कवकों की भूमिका

एस०पी० गौतम व अर्पणा मैत्रा

सारांश

इस अभिमत्र में *डैंड्रोकैलेमस स्ट्रिक्टस* की क्षेत्र में स्थापना और उसकी बढ़ने की दरों में सुधार लाने के लिए वैम कवकों की भूमिका का वर्णन दिया गया है।

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EVALUATION OF SOIL FERTILITY STATUS IN TEAK PLANTATIONS OF SOUTH INDIA

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Introduction

The forests are facing ever increasing pressure of fuel and firewood requirement from the villagers, raw material demand of the wood based industries etc. On the other hand, there is continuous decline of the forest land for use for a number of non-forestry purposes. The projected demands on the basis of a rise in population and the standard of living and increasing installed capacity of wood-based industries are considerably larger. Therefore, it has become necessary to maximise wood production from the limited forest areas in the country to meet the increasing demands.

In order to achieve this objective, it is necessary to establish commercial timber-lands by converting wastelands into productive ones. The other benefits arising out of growing tree crops are (i) conservation of ground water resources, (ii) prevention of soil erosion, (iii) gainful employment to rural work force, and (iv) increase in the productivity of the land thereby ensuring the guaranteed timber yield and manifold benefits to the country.

Nowadays, Teak (*Tectona grandis*), the king of timbers, is gaining momentum. Though the geographical and climatic conditions of India are well suited for Teak cultivation, the slump in annual production level of 20 million cubic metres over the last few years is observed. Since much of the natural Teak forests in the country have been over-exploited in the last four decades, commercial Teak plantations are being established throughout the country. In order to enhance the growth and health of teak plantations, scientific cultivation practices like fertilization, irrigation, intercultural operations to be given prime importance. Fertilizer recommendations based on the soil fertility status has a distinct advantage since it considers both the soil supplying power of nutrients and the crop nutrient requirement (Tisdale *et al.*, 1985).

Among the soil nutrient elements, the macro-nutrients viz., nitrogen, phosphorus and potassium play a key role in influencing Teak growth. Balanced nutrition is essential for getting good statured timber. Since nutrient imbalance creates deficiency/toxicity of nutrients in soil/plant, the present study was undertaken to evaluate the macro-nutrient status of some of the established commercial Teak plantations.

Materials and Methods

The present study was carried out in some of the commercial plantations of Sterling Tree Magnum (India) Ltd., which is considered as the single largest Teak producing company in India. The soil

samples from various plantations were collected at two different depths (30 and 60 cm). The description of the plantations is given in Table 1. The physico-chemical properties of soil like colour, texture, lime status, pH and electrical conductivity were determined as per the standard procedures outlined by Jackson (1973). Organic carbon, Alkaline $KMnO_4$-Nitrogen (Subbiah and Asija, 1956), Olsen - Phosphorus and Bray 1 - Phosphorus (Olsen *et al.*, 1954; Bray and Kurtz, 1945) and NH_4 OAc-Potassium (Stanford and English, 1949) of the soil samples were estimated to assess the fertility status of different plantations.

Results and Discussion

The physico-chemical properties of the plantations studied under the present investigation are given in Table 2.

The most ideal sandy loam texture was observed under all the plantation sites. Organic carbon in surface and sub-surface soils of the plantations indicated low content with not much variation. The soils of Veeravanallur and Panagudi plantations indicated pH varying from neutral to sightly alkaline range, while the other plantations were characterised by acidic pH. Soluble salt accumulation was not observed in any of the plantations.

The available nitrogen status of all the plantations showed low to medium levels. About 70 per cent of the samples of Veeravanallur, which is the oldest plantation, recorded lower levels of available nitrogen status. This might be attributed to the increased nitrogen uptake during earlier stage of the tree growth. This was followed by Panagudi plantation, located at the foothills of Western Ghats with undulated topography. The reason could be the loss of nitrogen as ammonia through volatilization particularly under slightly alkaline conditions. In addition, the wind induced erosion could have removed the soil organic matter present in the loosened top soils of Panagudi and Karuthapillaiyur plantations. However, the depleted nitrogen status may be replenished by the addition of leaf litter at a later stage (Negi *et al.*, 1995).

All the plantations studied invariably recorded poor phosphorus status. Phosphorus, being an immobile element in soil, gets fixed up by the iron and aluminium oxides present in red soils of all the plantations. Besides, the predominance of 1:1 kaolinitic clay mineral in acid soils could have fixed more phosphorus, hindering its release to available pool. The observations

Table 1

Details of Teak Plantations under study

Name of the plantation	District	State	Year of planting
Veeravanallur	Tirunelveli	Tamil Nadu	1992-94
Karuthapillaiyur	Tirunelveli	Tamil Nadu	1995
Panagudi	Tirunelveli	Tamil Nadu	1993-95
Gandarvakottai	Tanjore	Tamil Nadu	1995-96
Parvathipuram	Vishakapatnam	Andhra Pradesh	1994-95

Table 2

Physico-Chemical properties of soils under study

Plantation	Number of samples	Sampling depth (cm)	Properties						Available macronutrient status		
			Colour	Texture	Lime status	Organic carbon	pH	EC	Alkaline $KMnO_4$-N	Phos-phorous	NH_4OAc-K
Veeravanallur	31	0-30 30-60	Brown to red	Sandy loam	Nil	Low	Slightly acidic to slightly alkaline	Harm-less	Low (70%) medium (30%)	Low	Medium (85%) high(15%)
Karuthapillaiyur	21	0-30 30-60	Red	Sandy loam	Nil	Low	Slightly acidic to neutral	Harm-less	Medium (70%) low (20%) high(10%)	Low	Medium (50%) high (50%)
Panagudi	16	0-30 30-60	Red	Sandy loam	Nil	Low	Neutral to slightly alkaline	Harm-less	Medium (55%) low (45%)	Low	Medium(55%) high(45%)
Gandarvakottai	27	0-30 30-60	Red to brown	Sandy loam	Nil	Low	Acidic	Harm-less	Medium (75%) low(25%)	Low	Medium (80%) low(20%)
Parvathipuram	49	0-30 30-60	Brown to red	Sandy loam	Nil	Low	Acidic	Harm-less	Medium (70%) low (30%)	Low	Medium (90%) low (10%)

are in confirmity of Tomar and Tek Chand (1992).

Most of the samples taken at different plantations showed medium to higher levels of available potassium, thus proving good potassium supplying capacity of soil in all the plantations which will facilitate the normal uptake of other nutrients and water.

SUMMARY

In the present study, the available macro-nutrient status and the physico-chemical properties of soils at different Teak plantations of Sterling Tree Magnum (India) Ltd., were evaluated. It has been found that the nitrogen (Alkaline $KMnO_4$), phosphorus (Bray 1-P and Olsen-P) and potassium (NH_4OAc) status of the plantations were low to medium, low and medium to high levels, respectively. Thus, Soil Fertility Evaluation could form the basis for better discriminatory fertilizer recommendation to the growing Teak plantations of India for the maintenance of soil fertility status and to have sustainable Teak production.

दक्षिण भारत के सागौन रोपवनों की मृदा उर्वरता स्थिति का मूल्यांकन

डी० क्लार्सन व एस० माइथिली

सारांश

प्रस्तुत अध्ययन में स्टर्लिंगट्री मैग्नम (इण्डिया) लि० के विभिन्न सागौन रोपवनों की मृदाओं के बडे पोष्याहारों की उपलब्धि स्थिति और उनकी भौतरसायनिक विशिष्टताओं का मूल्यांकन किया गया है। पता यह चला है कि रोपवनों की नाइट्रोजन (क्षारीय के०एम०एन०ओ$_4$) फास्फोरस (ब्रे 1-पी और ओल्सन-पी) और पोटाशियम (एनएच$_4$ओएसी) स्थिति क्रमशः निम्न से मध्यम, निम्न और मध्यम से उच्च स्तर की है। अतः मृदा की उर्वरता स्थिति बनाए रखने और चिरकाल तक सागौन उत्पादन करते रहने के लिए भारत में सागौन रोपवन उगाने के लिए उर्वरता मूल्यांकन को समझबूझ कर उर्वरक देने की सिफारिश करने में उपयोग किया जा सकता है।

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VARIATION IN WOOD SPECIFIC GRAVITY OF *PINUS RADIATA* IN VICTORIA, AUSTRALIA

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Introduction

The commercial significance of (*Pinus radiata* D.Don) is rapidly increasing all over the world and particularly in Australia, New Zealand and Chile. It is one of the most widely planted exotic conifers worldwide. Wood density or Wood Specific Gravity has attracted most attention amongst all the intrinsic characteristics that define the quality of wood from this species. It is the most important wood characteristic for most of the commercial wood products.

Specific Gravity is not a simple wood characteristic but is a combination of many characters. It is determined by the proportion of early (spring) and late (summer) wood, cell size and cell wall thickness. Wood density is considered the best single index of wood quality because it is the most dependable characteristic for predicting pulp yield and quality and timber strength. Almost all wood characteristics in pine, including density, change significantly from pith to bark. Wood formed near the pith (central 5-15 rings) is called juvenile and that formed further away from the pith is mature wood. Wood properties also change dramatically within a single annual ring (Hodge and Purnell, 1993).

For most tree breeding programmes, improvement in specific gravity is not the major objective, but it is a supplementary to breeding for growth, form, pest resistance and adaptability. It has high heritability ranging from 0.5 to 0.6 (in both softwood and hardwood), with a large variation pattern, enabling good success in a breeding programme. It can be easily manipulated genetically because of the large tree-to-tree variation, the strong heritability, its low genotype x environment interaction and its major effects on yield and quality of wood (Zobel and Talbert, 1982).

Here, we report the results of analysis of variance for specific gravity and ring width between 3 clones of *Pinus radiata* selected in a breeding arboreteum and eleven individual trees of thirty years of age in a plantation in Creswick, Victoria, Australia. The objective of this study was to estimate genetic variability parameters of wood density within tree (age-related) and between trees (largely genetic variations). The study also computes the genetic gain which can be achieved by selecting the clone with the highest specific gravity.

Materials and Methods

Field Sampling : In this experiment, a Pressler Increment Borer, was used to take Increment cores of diameter size 0.5 cm, for the determination of wood specific gravity. Two ramets from each of the 3 clones in a

breeding arboreteum and eleven trees in a plantation population of *Pinus radiata* were sampled.

Cores were taken at breast height (1.4 m) across the whole cross section of the tree from the bark to pith or tree centre and upto the bark on the other side of the tree. Two cores were taken from each ramet from the opposing radii of each clone and one core was sampled from each tree. The cores were stored in water to retain the original moisture content before laboratory analysis.

Laboratory Sampling : The specific gravity was determined by the maximum moisture content method. After measuring ring width, the core was divided into individual rings and numbered from the pith towards the bark. From the ramets five annual rings (early wood + late wood) were counted on both ends of the core and 2 five-ring sections were cut out with a sharp blade. From the trees fifteen annual ring sections were taken. One section was labelled as sample A, the other as sample B. Green length (cm) of each sample was measured with a vernier callipers and recorded.

The first and the last annual rings from the sample were discarded because they were usually incomplete. The core samples were then air dried for a few days and their air dry weight (grams) was recorded. Then the samples were kept in the oven at 100°C for overnight drying and the next day the oven dry weight was measured. The oven dried samples were first cooled by placing in a desiccator until they reached ambient temperature and then weighed, immediately without letting them absorb moisture.

This process of overnight oven drying and next day weighing of samples was done for 4 consecutive days, till the weight of the samples became stabilised. The last day's weight was taken for calculating the specific gravity.

The formula used for the calculation :

Specific Gravity = Oven dry weight (gm)/ Green volume (cm^3)
Green Volume = pia x ($D^2/4$) x L, where,
D = diameter of core = 0.5 cm, and
L = length of core samples (cm).
Wood Density = Specific gravity/1000.

Statistical analysis was performed using SAS Computer Package (The SAS Institute, 1988). For the clones there were 23 observations in the data set and one value was missing. Data set had the following structure :

Clones	:	3
Ramets	:	2
Cores from each Ramet	:	2
Samples from each core	:	2

For the trees, there were 22 obeservations and the data set had the following structure :

Trees	:	11
Sample core from each tree	:	1
Samples from each core	:	2

The ANOVA linear Model used in the analysis was as follows :

Theoretical Model for clones :

$$P_{ij} = \mu + C_i + R_{j(i)} + E_{ij}$$

Where P_{ij} is the phenotypic value of observation. μ is the general mean of the population. T_i is the genotypic factor of the clone and corresponds to the variation

between the 3 clones (i varies from 1 to 3), $R_{j(i)}$ corresponds to the variation between the ramets nested in the clones. E_{ij} is the residual error in the model.

Theoretical Model for trees :

$$P_{ij} = \mu + T_i + E_{ij}$$

Where P_{ij} is the phenotypic value of observation. μ is the general mean of the population. T_i is the genotypic factor of the tree and corresponds to the variation between the 11 trees (i varies from 1 to 11) and j (sample from the core) varies from 1 to 2. E_{ij} is the residual error corresponding to the variation between cores within trees.

Observed Model

$$P_{ij} = P.. + (P_i - P..) + (P_{ij} - P_i)$$

Genetic parameter estimates : Variances were calculated using Expected Mean Square values obtained by the GLM command of SAS programme.

Clonal heritability was calculated using the formula :

$$h_c^2 = \sigma_g^2/\sigma_p^2$$

$$= \sigma_c^2/\sigma_c^2 + 1/n.\sigma_r^2 + 1/s.\sigma_e^2$$

Where h_c^2 = clonal heritability.

σ_c^2 = genetic variance between clones
σ_p^2 = phenotypic variance between clones
σ_e^2 = variance due to error between core sections
σ_r^2 = genotypic variance between ramets
n = no. of sample cores from each ramet
s = no. of sample cores from each clone.

Genetic Gain achieved by selecting individual clones was calculated as follows :

Genetic gain = h_c^2 x Selection Differential of the individual clone from the population Mean.

Ring width of the cores was calculated to find out the growth rate of the trees using the formula :

Ring Width (cm) = Green Length (cm)/ No. of Annual Rings.

Growth rate is defined as the width (cm) of an annual ring. The width was measured by counting the number of annual rings starting from the pith outwards to the cambium (Yang and Hazenberg, 1987). Sample cores were taken from the trees having approximately the same diameter size and which had the same age, so that there is no possibility of any effect of differential growth rate on specific gravity. Analysis of variance is carried out with the assumption that the variables have a normal distribution.

Results

Genetic gain for Specific Gravity : The genetic gain achieved by selecting clones was calculated.

Looking at Table 1, we find clone 3 has the largest average specific gravity at 0.39. The population Mean for all the 3 clones is 0.37.

Selection differential for clone 3 = 0.39-0.37 = 0.02. Clonal Heritability = 0.59.

Therefore genetic gain achieved by selection clone 3 = Clonal Heritability of specific gravity of wood x selection differential

= 0.59 x 0.02 = 0.012.

Table 1

Mean Specific Gravity and Mean Ring Width Table for Clones (in descending order) and comparison of Means using T Test (LSD)

Clone	Mean Specific Gravity		Clone	Mean Ring Width (cm)	
3	0.387	(0.01)	3	1.264	(0.10)
1	0.365	(0.01)	2	0.937	(0.10)
2	0.363	(0.01)	1	0.789	(0.10)
	Mean 0.37			Mean 0.99	
	CV% 3.18			CV% 10.09	
LSD between Mean Specific Gravity of Clones = 0.0128			LSD between mean Ring Width of clones = 0.1327		

Note : CV = Coefficient of Variation. The values in parentheses are standard deviations.

Table 2

ANOVA

Analysis of Variance for Specific gravity and Ring Width (cm) of the Pinus radiata clones

Source of Variation	Df	SS	MS	F value (vr)	Pr>F
		Specific gravity			
Variation between clones	2	0.0027	0.0013	9.54	0.0017
Variation between ramets within clone	3	0.0021	0.0007	5.02	0.0113
Error	17	0.0023	0.0001		
Total	22	0.0070			
		Ring width			
Variation between clones	2	0.95	0.47	46.76	0.0001
Variation between ramets within clone	3	0.091	0.030	3.00	0.0578
Error	18	0.182	0.010		
Total	23	1.219			

Probability level = 0.05.

Selection of the clone will give 0.012 times more gain than the original population.

% of genetic gain = gain in specific gravity/mean = 0.3222 = 32%.

Results and Discussions

Specific Gravity of clones : The average specific gravity of the three clones is 0.37 (0.01). Clone-3 has the highest specific gravity at 0.39 (Table 1). All the three clones

Table 3

Variance components for Specific Gravity and Ring Width (cm) of the three Pinus radiata clones.

Source of variation	Expected Mean Square	Variance Components
	Specific Gravity	
Clone	$\sigma_e^2 + 3.8\,\sigma_r^2 + 7.6\,\sigma c^2$	$\sigma_c^2 = 0.0000789$
Ramet (Clone)	$\sigma_e^2 + 3.8\,\sigma_r^2$	$\sigma_r^2 = 0.000147$
Error	σ_e^2	$\sigma_e^2 = 0.00014$
	Ring Width	
Clone	$\sigma_e^2 + 4\sigma_r^2 + 8\sigma c^2$	$\sigma_c^2 = 0.05535$
Ramet (Clone)	$\sigma_e^2 + 4\,\sigma_r^2$	$\sigma_r^2 = 0.00505$
Error	σ_e^2	$\sigma_e^2 = 0.0101$

Note: σ_c^2 = genetic variance between clones, σ_r^2 = genetic variance between ramets within clones.

From the variance we can compute heritability for specific gravity of clones.

1. Between Clones Heritability (Family Heritability) of clonal repeatability
$= h_c^2 = \sigma_c^2/\sigma_c^2 + 1/n.\sigma_r^2 + 1/s.\sigma_e^2$

where n = 4 and s = 8.

Therefore, h_c^2 = heritability for specific gravity between clones at the level of phenotypic means = 0.5888 = 58.88%.

Clonal Heritability for Ring Width of *Pinus radiata* = 0.9563 = 95%.

differed significantly from one another. This was reflected in the ANOVA results (Table 2) with significant ($P<0.0017$) F ratio of 9.54 and Error Mean Square (EMS) of 0.0001. The ramets nested in the clones behaved more or less the same, and varied less significantly with ($P<0.0113$), F ratio of 5.02. The linear model is accounting for 66% variation (Coefficient of determination = 0.66270) in the experiment. The low CV of 3.18% indicates that the variation between the 3 clones is not very large i.e. the population is not very variable. The largest variance component was accounted for by the ramets nested in clones (0.000147).

Ring width of clones : The clones also varied highly significantly for ring width ($P<0.0001$), F ratio of 46.76 and EMS = 0.010 (Table 2). The low average coefficient of variation at 10.09% indicated that the clones were not very variable. Within the clones, ring width varied non-significantly. The largest variance was between the clones (0.055). Clone-3 has the largest ring width with 1.26 cm, indicating that it is putting on more growth every year and has a faster growth rate. Clone-3 having a specific gravity larger than the average, also has the largest size annuals rings.

The ring width appeared to be under stronger genetic control with a very high clonal heritability of 95% as compared to

Table 4

Mean Specific Gravity and Mean Ring Width Table for Pinus radiata trees (descending order) and comparison of Means using LSD values

Tree No.	Mean Sp.Gr.	Rank	Tree No.	Mean Ring Width (cm)	Rank
10	0.588	1	2	0.361	1
11	0.580	2	5	0.341	2
5	0.561	3	9	0.333	3
6	0.561	4	6	0.326	4
1	0.540	5	11	0.323	5
2	0.522	6	4	0.316	6
3	0.520	7	7	0.307	7
7	0.516	8	1	0.304	8
9	0.515	9	10	0.290	9
8	0.491	10	3	0.287	10
4	0.485	11	8	0.255	11
Mean Sp. Gr.	0.534 (0.01)		Mean Ring width	0.313 (0.07)	
CV%	2.18		CV%	20.82	
LSD between Mean Specific Gravity of trees = 0.0257			LSD between Mean Ring Width of trees = 0.1434		

CV = Coefficient of variation. The values in parentheses are standard deviations.

Table 5

ANOVA

Analysis of Variance for Specific gravity and Ring Width of Pinus radiata trees.

Source of Variation	Df	SS	MS	F value	Pr>F
		Specific Gravity			
Variation between trees	10	0.0236	0.002360	17.39**	0.0001
Variation between cores within trees	11	0.00149	0.000135		
Total	21	0.02510			
		Ring Width			
Variation between trees	10	0.0168	0.00168	0.40	0.9220
Variation between cores within trees	11	0.0467	0.00424		
Total	21				

Table 6

Variance components for Specific Gravity and Ring Width (cm) of Pinus radiata trees

Source of Variation	Expected Mean Square	Variance component
	Specific Gravity	
Trees	$\sigma_e^2 + 2\sigma_t^2$	$\sigma_t^2 = 0.00111$
Error	σ_e^2	$\sigma_e^2 = 0.000135$
	Ring Width	
Trees	$\sigma_e^2 + 2\sigma_t^2$	$\sigma_t^2 = 0.0063$
Error	σ_e^2	$\sigma_e^2 = 0.00424$

Note: σ t^2 variance between trees, σ e^2= variance within trees.

specific gravity with hertibility of 59% in the *Pinus radiata* clones. The same results were obtained for wood density components, which were under stronger genetic control than overall weed density in juvenile *Pinus radiata* D.Don (Nicholls *et al.*, 1980). The specific gravity is under strong genetic control (59%) so that the clones will respond well to selection in tree improvement programme, even though genetic variation is low. The genetic gain achieved by selecting Clone-3 having the highest specific gravity (0.39) was 32% which is considerable. Therefore, in a breeding programme, specific gravity and ring width with moderate to high heritabilities can be utilized to achieve gains.

Specific gravity of individual trees : The 11 individual trees sampled were significantly different from each other with significant (P<0.0001), F ratio of 17.39. The average coefficient of variation of weed specimens from the eleven trees was 2.181%. Results of Table 4, indicate that the tree No. 10 has the highest specific gravity (0.588) followed by tree No. 11 (0.58). Therefore, if these two trees are selected in a tree improvement programme, the resultant progeny population will give greater gains than the original population. The largest variance component was for between the trees (0.0011).

Ring width of individual trees : The analysis of variance results (Table 5) indicate there is no significant difference between the 11 trees for ring width. The F ratio (variance ratio) is low at 0.40. Tree No. 2 has the largest ring width (0.361 cm) followed by Tree No. 5 (0.341 cm) indicating these two trees have higher growth rates and Tree No. 8 with narrowest annual rings (0.255 cm) is a slow growing tree with low growth rate per year. The average coefficient of variation for the 11 trees was 20.83%. Tree Nos. 10 and 11 having substantially higher specific gravities than average, are ranked ninth and fifth respectively for ring width. The largest variance component was accounted by individual trees (0.0063).

Conclusions

The pattern of variation for within clone and between clone specific gravity and ring width was broadly similar for all three *Pinus radiata* clones in the breeding arboreteum. Such uniformity in wood quality among trees from seed does not exist. The high clonal heritabilites for both specific gravity and ring width can be utilized in breeding programmes to increase genetic

gains and plantation yields through selection of superior clones.

This study of Radiata pine wood in plantation indicates the existence of significant differences among the individual trees for specific gravity. About 80% of total variation is accounted for by differences between the individual trees and the rest 20% by experimental error. For all wood characteristics that have been adequately studied to date, variation among trees of the same age growing on the same site has always been found to be large (Zobel and Talbert, 1982).

There are hundreds of references on tree-to-tree variation in wood quality. The one sure thing in forestry is that wood specific gravity as well as other wood qualities will vary greatly from tree to tree, regardless of the species or where the trees are grown. Since, heritability of wood characteristics is also usually high, the two ingredients for good gains from a tree improvement programme are present (Zobel and Talbert, 1982).

This study further our understanding of phenotypic variation in *Pinus radiata* plantations. Genetic improvement of specific gravity (and therefore the mechanical properties of Radiata pine) could be based on the choice of individuals that produce high density wood. Final decision regarding the weightage given to wood density and growth rate in selection indices will require more information about their relative contributions to product value in this species. It should be remembered, however that increasing emphasis on selection for one or the traits will always be accompanied by a smaller response in the other. Maximum gains cannot be obtained on both traits at the same time.

SUMMARY

The results of analysis of variance for specific gravity and ring width between three clones of *Pinus radiata* selected in eleven individual trees of thirty years of age in a plantation are reported.

विक्टोरिया, आस्ट्रेलिया में *पाइनस रेडियाटा* की लकड़ी में आपेक्षिक गुरुत्व में अन्तर पाया जाना

फातिमा शीरीन, दिनेश कुमार व लिओन पेडेरिक

सारांश

पाइनस रेडियाटा रोपवन में 30 वर्ष उम्र वाले चुने हुए 11 वृक्षों के तीन कृन्तकों के आपेक्षिक गुरुत्व और वलयों के बीच की चौडाई में पाई जाने वाली विभिन्नता के विश्लेषण के परिणाम इस अभिपत्र में सूचित किए गए हैं।

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STUDIES ON GROWTH PERFORMANCE OF LOCAL TREE SPECIES AFTER COPPICING

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Introduction

Importance of agroforestry has perhaps never received as much attention as it needs to-day. Agroforestry generally involves a close interaction of trees with crops and/or livestock. For advancement of agroforestry, selection of suitable tree species for specific region plays an important role.

Trees in woodlots may be coppiced to produce fuelwood. Trees in fodderlots or in hedgerow-intercropping systems are often lopped to produce fodder and mulch and where necessary, to reduce shade on an adjacent crop. Coppicing increases the ground cover per tree so that fodder needs to be planted and greater use can be made of those already growing - an advantage if planting stock is in short supply. Also, the vertical shoots can be repeatedly harvested as they are rapidly replaced by new shoots, there is less need to weed than when replanting, and one has all the other advantages of rotation cropping (Plucknell *et al.*, 1970). Regular coppicing will also keep the leafy shoots accessible for harvesting or browsing and by restricting the development of the boles and woody frames, coppicing will increase the proportion of dry matter going to new leafy shoots. Coppicing, the optimum cutting frequency to ensure survival and rapid recovery, will depend on the species, environment and amount of foliage left. Successful coppicing is possible only when the individual stumps and root systems are large, implying a minimum tree size and spacing, combined with timely coppicing and a minimum coppice cycle. There are no rules about this; many willows in Europe can be coppiced annually at very close spacings, tea in the tropics can be coppiced every 4 to 6 years, while sweet chestnut and aspen in temperate regions yield most on coppice rotations of 10 to 25 years (Berry and Steill, 1978). By analogy with grasslands, the optimum cutting frequency may be shorter with increased mineral nutrition. Each species brought into an agroforestry system for fodder or mulch production will need to be tested.

Study Area

The study was carried out ICAR Krishnagiri Farm (Langol hills) Manipur (between 23.83°N-25.68°N latitude and 90^0-94.27^0 E longitude) which is located on the periphery of Imphal. The elevation of the farm varies from 800 m to 1050 m above msl. Soils were acidic with pH value ranging between 4.4 and 4.9, clay loam in texture, organic carbon 1.76%, available N 250 kg

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ha^{-1}, available P 8.8 kg ha^{-1} and K 150 kg ha^{-1} and CEC 6.5 to 8.3 c mol (+) kg^{-1}. The maximum temperature reaches upto 32°C during the month of August and minimum temperature reaches minus 1°C during January. The rainfall (about 1500 mm annually) in the area is distributed with moderate rains in the month of February, March and April and heavy rains during June to September. Mean maximum relative humidity (82%) was recorded in the month of July and October and minimum in April (60%).

Materials and Methods

The experiment was started in 1987 with 15 (fifteen) local tree species viz., *Ailanthus excelsa, Albizia procera, Artocarpus lacoocha, Bauhinia purpurea, Celtis australis, Ficus cunia, Ficus hispida, Figaenia pruox, Grewia optiva, Litsaea polyantha, Lylosma longifolia, Phoebe haissiana, Quercus dealbata, Quercus pachyphylla* and *Schima wallichii*. About 15 years old trees were coppiced at 15 cm above the ground level in the month of June, 1987. Three plants were selected for each species. The observations were recorded in seven characters viz., height (m), collar girth diameter (cm), no. of branches, canopy (m^2), crown height (m), green fodder yield (kg/tree) and dry matter percentage from each tree species.

Results and Discussion

Data on rate of growth performance i.e. height, girth, no. of branches, canopy, crown height, green fodder yield and dry matter percentage were recorded annually. Maximum height was recorded in *Grewia optiva* (9.46 m) followed by *Ailanthus excelsa* (7.95 m) and *Celtis australis* (7.93 m). Maximum collar girth diameter was recorded in *Grewia optiva* (89.67 cm) followed by *Ficus hispida* (87.50 cm) and *Celtis australis* (87.00 cm). Number of branches was recorded maximum in *Ficus hispida* (19.00) and *Grewia optiva* (19.00) followed by *Figaenia pruox* (18.00) and *Litsaea polyantha* (18.00). Maximum canopy was recorded in *Ficus hispida* (42.45 m^2 followed by *Grewia optiva* (39.64 m^2) and *Celtis australis* (32.40 m^2). Maximum crown height was recorded in *Grewia optiva* (6.96 m) followed by *Ficus hispida* (6.1 m) and *Ailanthus excelsa* (5.38 m). Maximum green fodder yield per tree was recorded in *Grewia optiva* (95.50 kg/tree) followed by *Ficus hispida* (92.50 kg/tree) and *Lylosma longifolia* (53.50 kg/tree). Maximum dry matter percentage was recorded in *Quercus pachyphylla* (50.3%) followed by *Quercus dealbata* (50.0%), *Celtis australis* (40.0%) and *Schima wallichii* (40.0%). *Bauhinia purpurea* and *Ficus hispida* had lowest dry matter percentage (14 and 16% respectively) (Table 1).

From the above results, *Grewia optiva* gives maximum height, collar girth diameter and green fodder yield due to more number of branches and collar girth followed by *Ficus hispida*. Among the 15 local multipurpose species, the above two species are more suitable for coppicing for green fodder and fuelwood.

Table

Growth performance of local

Sl. No.	Species	Local name (Manipur)	Height (m) (increase growth %)		Collar Girth (cm). (increase growth %)	
			1988	1991	1988	1991
1	*Ailanthus excelsa*	Tairen	3.60 (-)	7.95 (120.83)	26.30 (-)	58.50 (122.43)
2	*Albizia precera*	Khal	3.50 (-)	7.17 (104.86)	21.30 (-)	68.54 (221.78)
3	*Artocarpus locoocha*	Heirikothong	2.27 (-)	6.12 (169.60)	11.66 (-)	37.00 (217.32)
4	*Bauhinia purpurea*	Chingthrao	3.53 (-)	6.48 (83.57)	27.70 (-)	69.55 (151.08)
5	*Celtis australis*	Heikreng	3.90 (-)	7.93 (103.33)	17.30 (-)	87.00 (402.89)
6	*Ficus cunia*	Heirit	3.30 (-)	6.17 (86.97)	27.70 (-)	68.74 (148.16)
7	*Ficus hispida*	Ashi heibong	2.99 (-)	7.30 (144.14)	19.00 (-)	87.50 (360.53)
8	*Figaenia pruox*	Sileima	1.92 (-)	3.85 (100.52)	12.30 (-)	40.25 (227.24)
9	*Grewia optiva*	Yauon	4.02 (-)	9.46 (135.32)	30.70 (-)	89.67 (192.08)
10	*Litsaea polyantha*	Tumitla	2.75 (-)	6.35 (130.91)	21.30 (-)	59.38 (178.78)
11	*Lylosma longifolia*	Longleishang	2.64 (-)	6.60 (150.00)	15.80 (-)	49.27 (211.84)
12	*Phoebe haissiana*	Uningthou	2.54 (-)	5.10 (100.79)	16.20 (-)	64.35 (297.22)
13	*Quercus dealbata*	Sahi	3.48 (-)	6.15 (76.72)	19.20 (-)	37.00 (92.71)
14	*Quercus pachyphylla*	Kuhi	2.56 (-)	4.75 (85.55)	15.80 (-)	28.75 (81.96)
15	*Schima wallichi*	Utsoi	2.44 (-)	6.75 (176.64)	14.80 (-)	65.00 (339.19)

1

tree species after coppicing

No. of Branches 1988	No. of Branches 1991	Canopy (m²) 1991	Crown height (m) 1991	Green fodder yield (kg/plant) 1991	Dry matter (%) (kg/plant) 1991	Remarks
7.80	13.00	5.75	5.38	15.75	33	Timber, fodder, fuel
12.80	9.00	22.91	4.42	30.00	18	Fuel, fodder & timber
15.00	16.50	6.46	3.30	24.75	31	Fruit, fuel & timber
20.00	15.00	15.82	4.63	37.50	14	Fodder, fuel, poles, ornamental plant
25.00	12.00	32.40	4.54	25.00	40	Firewood, fodder, poles, timber
19.60	17.50	23.85	3.71	25.75	24	Fodder, fuel, fruit
15.30	19.00	42.45	6.10	92.50	16	Fuel, fodder
13.70	18.00	17.54	2.25	22.70	38	Fuel, poles, fruits
25.20	19.00	39.63	3.96	95.50	21	Fodder, fuel, timber
12.00	18.00	15.58	3.55	31.75	22	Timber, fodder, poles, sericulture
18.30	12.00	11.07	4.85	53.50	30	Medicinal, fuel, poles
15.00	16.50	6.01	2.65	32.50	25	Timber, fuel, poles
39.50	17.00	9.35	4.96	10.25	50	Fuel, fodder, poles
11.83	16.00	16.75	3.05	15.05	50.3	Fuel, poles
20.83	8.00	15.60	4.12	15.76	40	Timber, fodder, fuel, sericulture

SUMMARY

A study was conducted during 1988 to 1991 with 15 (fifteen) local multipurpose tree species for identifying maximum yield of fuelwood, fodder, pole, timber etc. about 15 years old tree species coppiced at 15 cm above the ground level at Krishnagiri Farm, Langol Hills, ICAR Research Complex for NEH Region, Manipur Centre, Imphal. The maximum height (9.46 m), girth (89.67 cm) and number of branches (19 nos.) was recorded in *Grewia optiva* followed by *Ficus hispida*, *Celtis australis* and *Aillanthus excelsa*. The maximum canopy was recorded in *Ficus hispida* (42.44 m²) followed by *Grewia optiva* and *Ficus cunia*. Maximum crown height was in *Grewia optiva* (6.69m) followed by *Ficus hispida* and *Aillanthus excelsa*. The maximum fodder (green) yield was recorded in *Grewia optiva* (95.5 kg/plant) followed by *Ficus hispida* and *Bauhinia purpurea*. The maximum dry matter (%) was recorded in *Quercus pachyphylla* (50.3%) followed by *Quercus dealbata* and *Schima wallichii*.

स्थूणकर्तन के उपरान्त स्थानीय वृक्ष जातियों की वृद्धि सक्रियता का अध्ययन

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सारांश

1988 से 1991 के दौरान 15 स्थानीय बहुप्रयोजन वृक्ष जातियों का अध्ययन भूमितल से 15 सेमी० ऊंचाई के ऊपर स्थूणकर्तन करने के बाद उनकी ईंधनकाष्ठ,चारा,बल्ली और प्रकाष्ठ आदि की अधिकतम प्राप्ति का पता लगाने के लिए कृषणगिरि प्रक्षेत्र, लागोल पहाडियाँ, उत्तर पूर्वी पर्वतीय क्षेत्र, आईसीएआर रिसर्च परिसर मणिपुर केन्द्र, इम्फाल में किया गया। अधिकतम ऊंचाई (9.46मी०) गोलाई (89.67%) और शाखाओं की संख्या (19) *ग्रीविया आप्टिवा* में पाई गई जिसके बाद अनुक्रम में *फाईकस हिस्पिडा*, *केल्टिस आस्ट्रेलिस* और *एलेंथस एक्सेलसा* रही। अधितम विवान *फाईकस हिस्पिडा* (42.44 मी०) में बना जिसके बाद अनुक्रम में *ग्रीविया आप्टिवा* और *फाइकस कूनिया* रही। छत्र की अधिकतम ऊंचाई *ग्रीविया आप्टिवा* (6.96 मी०) की रही जिसके बाद *फाइकस हिस्पिडा* और *एलेन्थस एक्सेल्सा* रही। अधिकतम चारा (हरा) प्राप्ति *ग्रीविया आप्टिवा* से (95.5 किग्रा/पादप) अभिलिखित हुई जिसके पश्चात् *फाइकस हिस्पिडा* और *बौहीनिया पर्पूरिया* रही। अधिक शुष्क पदार्थ (%) *क्वेरकस पैचिफाइला* (50.3%) से मिला जिसके पश्चात् *क्वेरकस डिएल्बेटा* और *स्किया वालिशाई* रही।

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RESEARCH NOTES
(I)

NEW HOST RECORD AND HOST SELECTION BEHAVIOUR OF SOME ENTOMOPHAGOUS INSECTS OF FORESTRY TREE SPECIES OF ARID AND SEMI-ARID REGION

Entomophagous insects (parasitoids and predators) are major factors in natural biological control, acting as regulators of host insects. Successful reproduction by entomophagous insects is dependent on the location of suitable hosts or prey on which to oviposit or feed. The most extensive investigations to obtain good quantitative information on the number and fate of the various life stages of insects, and their natural enemy complexes are difficult in the arid and semi-arid region. A variety of insects cause considerable damage to Social Forestry nurseries and plantations thus adversely affecting the growth and biomass. Biological control methods have immense potential in safeguarding plantations and nurseries from such insect attack (Murugesan *et al.*, 1997). Further, this type of insect check measure forms the central component of an integrated pest management, affording sustainable control of pests without environmental hazards. However, parasitoids-host insects-host plant interactions have not been investigated steeply in any part of its habitat. Considerable information on the pests of *P. cineraria* has been reported by Parihar (1993). This investigation highlights the greater adaptability and flexibility of some entomophagous insects to exploit the conditions to their advantage. Velayudhan (1987) indicated that the egg output of the host influences the percentage parasitism. Price (1980) reported that the parasitoids adapted to a particular host in its natural habitat may prove ineffective against the same insect in a new niche, mainly because of changes in pattern of host abundance and distribution that accompany the shift to a new habitat. In the light of such an understanding, effeorts have been made to investigate the existence of some natural biological control agents in the arid and semi-arid ecosystem.

The damage to the seedlings was negligible during pre-monsoon period as the insect activity declined. With the onset of monsoon, the activity of insects increased and thereby maximum damage of seedlings was observed. Parasitoid and predator complexes recorded in Social Forestry stands during our survey, play a major role in controlling the outbreaks of insect pests of arid and semi-arid regions. The interrelationships among host plants - herbivore insects - natural enemies are presented in Table 1.

Survey of host plants - herbivore insects - natural enemies was carried out under different forest nurseries in and around Jodhpur District, Grass farm, Lokswel, Osian, Phalodi nurseries; different planting trials of Arid Forest Research Institute, national/international trials of *A. indica* (Neem); *A. nilotica* (Babul) and *D. sissoo* (Shisham) and the plantations of other Districts of Rajasthan - Bikaner,

Chattargarh and Jaisalmer. A total of 16 species of insects and 8 species of natural enemies were found to be associated with the nurseries and plantations. The natural enemy complexes were found in abundance particularly in Neem, Babul and Shisham and bringing down the populations of some lepidopterous pests, *A. janata* (Noctuidae), *L. koenigana* (Eucosmidae), *B. variegata* (Geometridae) and *Eurema* sp. (Pieridae). The lepidopterous eggs laid on Neem, Babul and Shisham were bred and identified as *T. chilonis, T. roi, T. achaea* and *T. japonicum* during the survey. All these parasitoids (trichogrammatids) are recorded first time from the eggs of *A. janata, L. koenigana, B. variegata* and *Eurema* sp. The other recorded parasites from these pests are *Eupelmid* sp., *Proleurocerus fulgoridis, Apanteles* sp. and the predator *Chrysopa scelestes.*

Eupelmid sp. (Eupelmidae: Chalcidoidea), an effective egg parasitoid was found to parasitise a wide variety of insect eggs in the field conditions, and play a major role in bringing down the populations of *O. nitidula* (Acrididae), *P. affinis* (Curculionidae), *H. prominulus* (Coreidae), *Lymantria* sp. (Lymantridae) and *H. dentatus* (Pentatomidae) which are often destructive and cause mortality up to 10-20 % in the nursery and young plantations of *A. indica, P. cineraria* and *A. holoceracia*. Both nymphs and adults of *H. prominulus* and *H. dentatus* suck sap from the foliage and growing shoots causing "die back". Alzouma (1995) shown that *Eupelmid* was an effective control agent against the storage pests *Bruchidius atrolineatus* and *Callosobruchus maculatus*. In the field on *P. cineraria* in India, 42.08% parasitism of *H. prominulus* was due to *Eupelmid. P. fulgoridis* (Encyrtidae : Chalcidoidea), an effective egg parasitoid was reported for the first time in this region on *E. tomentosa* (Hemiptera: Eurybrachidae) and this pest was also recorded damaging the tender leaves of a wide variety of forestry tree species viz. *A.indica, A. nilotica, D. sissoo, A. holoceracia, A. ampliceps, P. cineraria, A. lebbek, Z. mauritiana, A. tortilis, C. siamea, Deudonia* sp. and *Reliya* sp.

Apanteles sp. (Braconidae), the valuable larval parasites recorded on the target pests of arid and semi-arid regions helps to check the defoliators such as *L. koenigana, B. variegata, A. janata, Eurema* sp., *E. fraterna, N. blitealis* (*Moringa* defoliator) and *Lymantria* sp. *E. fraterna* (Lymantridae), larvae of this pests are defoliators and considered to be the potential pests of many forestry tree species viz. *A. indica, P. cineraria, A. nilotica, A. holoceracia, D. sissoo, Z. mauritiana, A. tortilis, C. siamea* and *E. officinalis. Apanteles* parasites are very effective larval parasites more commonly found on lepidopterous insects.

The green lace-wing *C. scelestes* (Chrysopidae) was found to be an efficient predator of flower thrips, *M. distalis, T. hawaiiensis, T. tabaci, G. dampfi* and *D. bispinosus* were observed infesting flowers of *M. oleifera, P. aculeata, C. siamea, A. tortilis, T. undulata* and *Z. mauritiana*. It may be noted that all these hosts recorded here are the new hosts reported for these flower thrips in India (Murugesan and Shivesh Kumar, 1996). Since *C. scelestes* adults are not predatory, the feeding behaviour of the larvae involves a series of stimulus response events as evident in all the predatory insects. Like anthocorids and coccinellids, *C. scelestes* detect the presence of the prey only by the contact of mandibles. After immobilising the prey by injecting the saliva, the larvae sucked out the fluid

Table 1

Parasitoids-Host insects-Host plant interactions recorded from arid and semi-arid regions

Parasitoids/ Predators	Host insects	Host plants	Locality
Trichogramma chilonis	*Lespeyresia koenigana*	*Azadirachta indica*	Jodhpur
T. roi	*Achaea janata*	*Acacia nilotica*	Osion
T. achaea	*Boarmia variegata*	*Dalbergia sissoo*	
T. japonicum	*Eurema* sp.		
Eupelmid sp.	*Oxya nitidula*	*A. indica*	Jodhpur
	Pempherulus affinis	*Prosopis cineraria*	Osion
	Homoeacerus prominulus	*Acacia holoceracia*	Bikaner
	Lymantria sp.		Jaisalmer
	Halys dentatus		
Proleurocerus fulgoridis	*Eurybrachis tomentosa*	*A. indica*	Jodhpur
Apanteles sp.	*Lymantria* sp.	*A. ampliceps*	Bikaner
	Eurybrachis tomentosa	*P. cineraria*	
	Euproctis fraterna	*Albizia lebbek*	Jaisalmer
	Noorda bilealis	*Zizyphus mauritiana*	Phalodi
		A. tortilis	
C. scelestes	*Megalurothrips distalis*	*C. siamea*	Chattargarh
	Thrips hawaiiensis	*Deudonia* sp.	Mandore
	Dendrothrips bispinosus	*Reliya* sp.	
	Frankliniella dampfi	*Emblica officinalis*	
	Thrips tabaci	*Tecomella undulata*	
		Pongamia pinnata	
		Moringa oleifera	
		Parkinsonia aculeata	

contents (Suresh Kumar, 1985). Field observations on the parasitisation rate of different parasitoids like trichogrammatids, *P. fulgoridis*, *Eupelmid* sp., *Apanteles* sp. and the predator *C. scelestes* revealed 50-60% parasitisation/predation on the target pests of arid and semi-arid tree species. Among these parasitoids, *P. fulgoridis* and *Eupelmid* sp. showed a higher percentage of parsitism. The parasitisation of trichogrammatids appear to be a dominant group of parasitoids play an important role in regulating the population fluctuation of *A. janata*, *L. koenigana*, *B. variegata* and

Eurema sp.

Changes in the level distribution of natural enemy complexes in the various forestry tree species might be a multiplicity of factors of tri-trophic interactions and have to be taken into consideration involving plant-produced, insect-produced and parasitoids-produced allomones, kairomones and synomones. It is here that the influence of Neem, Babul, Shisham and other forestry tree species exhibiting various degrees of attraction on the suitability of the pests to their parasitoids forms an important aspect deserving considerable attention. The semi-chemicals play an incisive role in the host or prey selection of most of the parasitoids may originate from plants, from the host or prey and from other entomophagous insects. Herbivorous hosts may be attacked by a particular entomophagous insect on the same plant species but not with edequate efficiency on others. Hence semio-chemicals characteristic of plant assemblages are important in the abundance and performance of entomophagous (Nordlund, 1984).

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(II)

OCCURRENCE OF BLISTER-BARK DISEASE IN *CASUARINA* HYBRID (*C. EQUISETIFOLIA* X *C. JUNGHUHNIANA*)

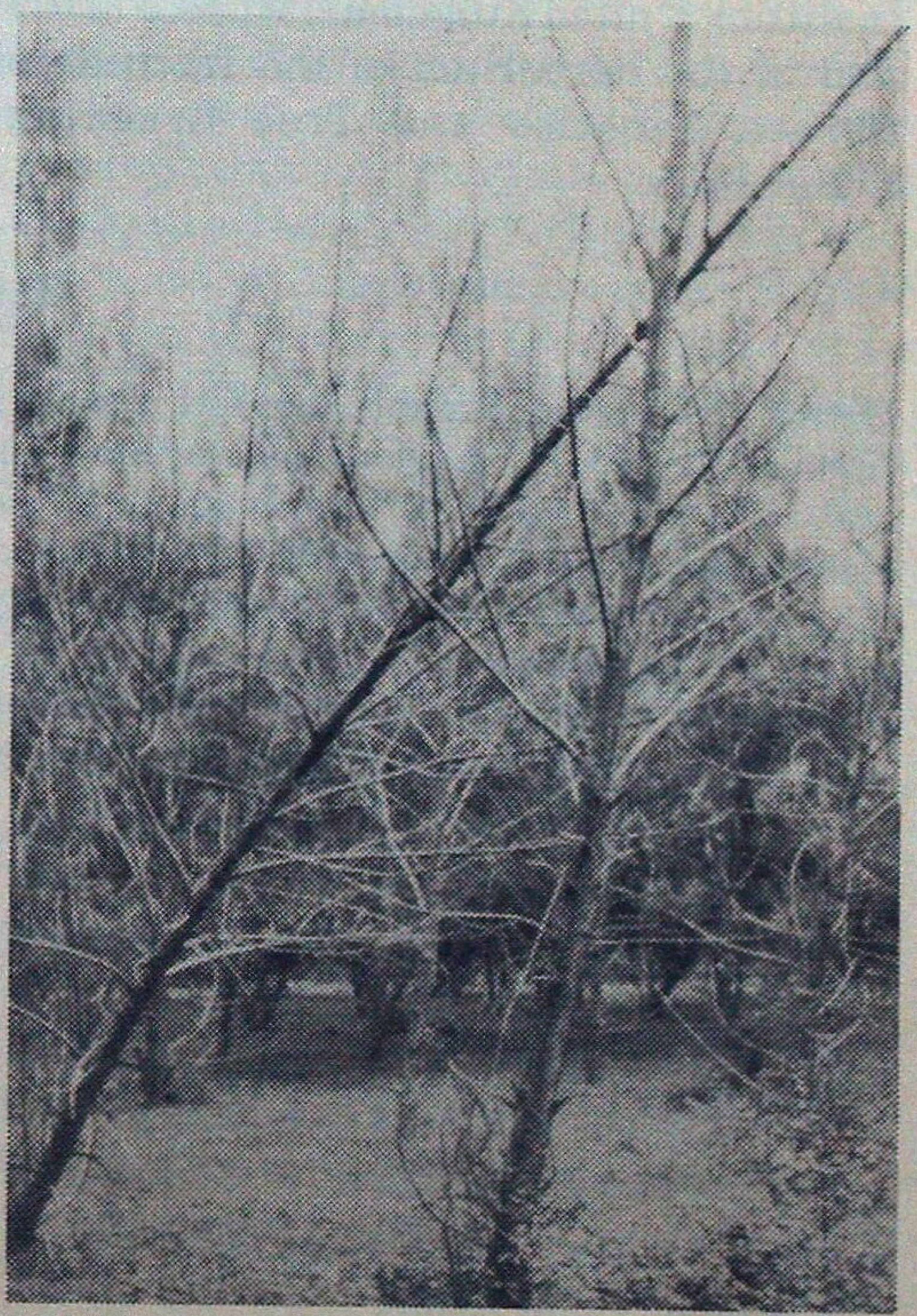
The *Casuarina* hybrid (*C. equisetifolia* x *C. junghuhniana*) widely used for commercial planting in Thailand has excellent stem form. The hybrid was introduced from Thailand to India, in 1951, as air layers and planted in Tamil Nadu (Kondas, 1981). These plants show good growth performance in Tamil Nadu and interestingly they bear only male flowers.

During a recent survey in the 1989 introduction trial of *Casuarina* hybrid in Neyveli (Tamil Nadu, India), being conducted by Tamil Nadu State Forestry Research Institute, mortality of trees due to blister-bark disease caused by *Trichosporium vesiculosum* Butler (*Nomen illegitimum*) was observed.

Fig. 1

Affected trees of *Casuarina* hybrid exhibiting blisters on the stem

Fig. 2



Drying up of *Casuarina* hybrid trees

Affected trees exhibit yellowing and drying of needles. In bark tissue of affected trees, cushiony elevations which enclose numerous conidiospores of the pathogen, known as 'blisters', develop (Fig. 1). Subsequently, the blisters peel-off releasing the black powdery spores. During advanced stages of infection, the entire tree dries up (Fig. 2).

Microscopic observation of the sections of blisters showed typically branched conidiophores and conidia of *T. vesiculosum* (Butler, 1905; Narayanan and Sharma, 1996). *T. vesiculosum* could also be isolated on potato dextrose agar, from all the diseased specimens. The identity of the fungus was confirmed by comparing with known isolates. The diseased specimens have been deposited in the International Mycological Institute, United Kingdom (IMI no. 374102) and in the herbarium of the Institute of Forest Genetics and Tree Breeding, Coimbatore.

Though there is a report on the occurrence of blister-bark symptoms in a plantation of the *Casuarina* hybrid at Pak Thor in Ratchaburi, Thailand (Narayanan *et al.*, 1996) apparently no detailed studies have been conducted to confirm the etiology. the present report confirms the susceptibility of *Casuarina* hybrid to blister-bark and this is also the first record of the disease on the host from India.

Though many suggested control measures are available, none of them is found to give effective remedy for the disease. Therefore, selection and breeding for blister-bark disease resistance seems to be the viable long term strategy for managing this disease. In view of the high adaptability of this hybrid to Indian conditions and because of its scope in future plantation programmes, studies in these lines are being conducted in the Institute of Forest Genetics and Tree Breeding, Coimbatore.

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Institute of Forest Genetics
and Tree Breeding,
Coimbatore (Tamil Nadu)

C. Narayanan,
K.R. Sasidharan
and A.S. Sampath Kumar*

* State Forestry Research Institute, Kolappakkam,
Chennai (Tamil Nadu).

(III)

ON THE OCCURRENCE OF A RARE SNAKE IN ARUNACHAL PRADESH

During the course of faunestic studies in Arunachal Pradesh the authors have collected a large number of snake species. While carrying out the Taxonomic studies on ophidion fauna in the State on these preserved specimens deposited at the Forest Zoology Division of the State Forest Research Institute, Itanagar has revealed a very interesting specimen which was found to be the second collection of this species. This paper deals with this finding.

Description
(*Oligodon erythrorhachis*)

It is a small (probably juvenile) snake with body brown above to dull brick colour, Cross bars of light black colour on the body, ashy white below with squarish black spots at the outer margin of ventral. There is a median red-stripe which passes along the belly and beneath the tail. It disappears anteriorly before the throat (may be due to formalin action in the preserved condition). Number of bands (Body + Tail; 24+7) (Figs. 1-2, dorsal view, ventral view and the red median strip enlarged).

Snout-vent length - 290 mm; Tail length - 90 mm; Tip sharply pointed; diameter at mid body - 8 mm.

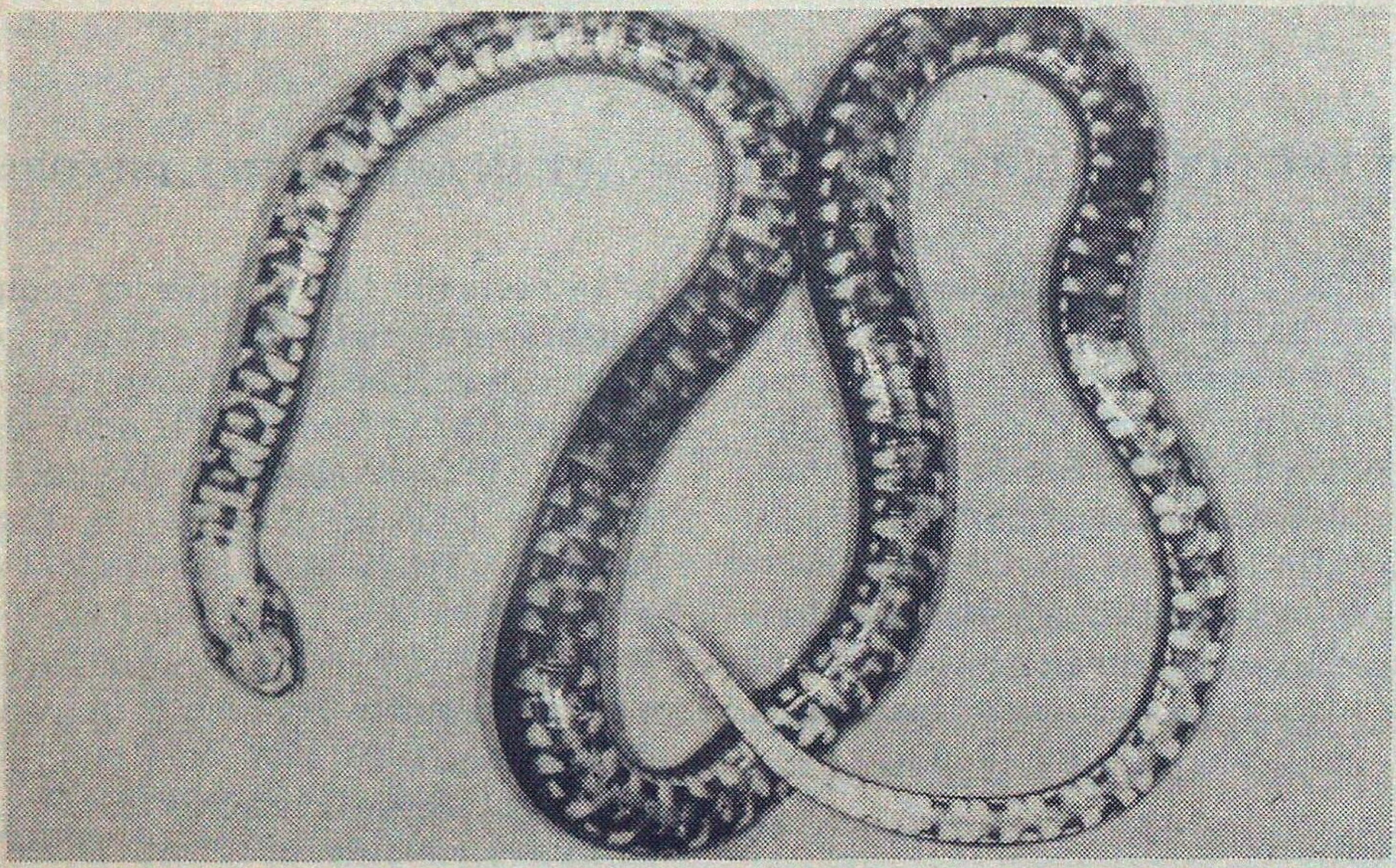
Infralabials - 7L, 8R; preoculars - 1L, 1R; postoculars - 2L, 2R; nasal undivided touching the supralabials 1&2; Loreals absent; prefrontal is fused with what would have been the loreal; anterior temporals touch supralabials 5&6; anterior genials about one and half times of posterior genials. The ventral preceding the anal plate is paired. This specimen was collected in Aug. 1993 at Chessa (Papumpare District, Arunachal Pradesh) at an altitude of 162 m. This species was originally described by Wall as *Oligodon erythrorhachis* (1910) from a single specimen available to him and was collected in 1910 from Namsang, Jaipur District of Assam (Presently this place is in the eastern side of Tirap District of Arunachal Pradesh). The earlier records and the text in the field of herpetology reveals that this may be the second recorded specimen in the world, which was confirmed by the authorities on snakes at the British Museum, U.K. recently. (Pers. Comm. M.L. Colin McCarthy - Natural History Museum, U.K. and Dr. J.C. Daltry - Flora and Fauna International). Thus the present finding has great significance which points out to the highly threatened nature of the species which is also endemic to Arunachal Pradesh.

Salient diagnostic characters for field identification are given in Table 1.

Conservation

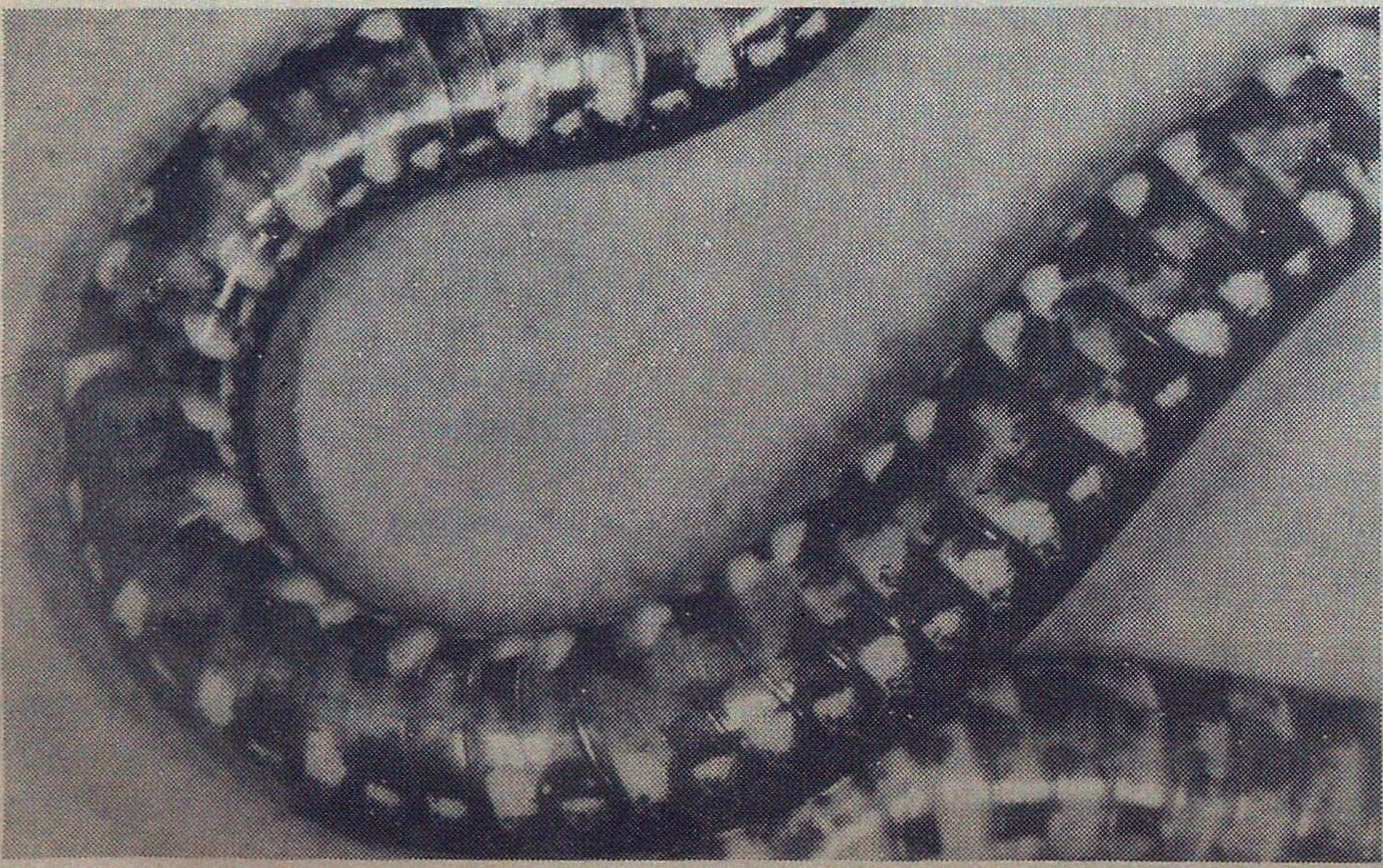
In the present day context in the State of Arunachal Pradesh it is observed that forest cover is being depleted gradually. Vast forested areas are being cleared for either agriculture, horticulture-like

Fig. 1



Oligodon erythrorhachis

Fig. 2



Oligodon erythrorhachis - details of ventral scales

Table 1

Salient diagnostic features of Oligodon erythrorhachis

Scientific Name :	*Oligodon erythrorhachis*	
Common name :	Red-striped Kukri	
Scale round the Body		15:15:13
Ventrals		145
Anal		2
Caudals (paired)		54
Supralabials:	L.	7
	R.	7
Supralabials (touching ocular)	L.	3,4
	R.	3,4
Temporals	L.	1+2
	R.	1+2

practices or for other developmental activities. Unscientific and over-exploitations too has taken its toll on the habitat.

To save this interesting species from possible extinction, we need to have thorough biological research on the species. Efforts should be made to conduct detailed survey for finding out its distribution and habitat preferences with adequate conservation measures adopted. The species should survive for posterity.

Acknowledgements

The authors are thankful to Shri G.P. Shukla, PCCF, Shri M.L. Deori, Director, SFRI for their encouragement and facilities provided during the study. We are also thankful to M.L. Colin-McCarthy, Natural History Museum, U.K. and Dr. J.C. Daltry, Flora & Fauna International for confirming the identity of the species and useful suggestions.

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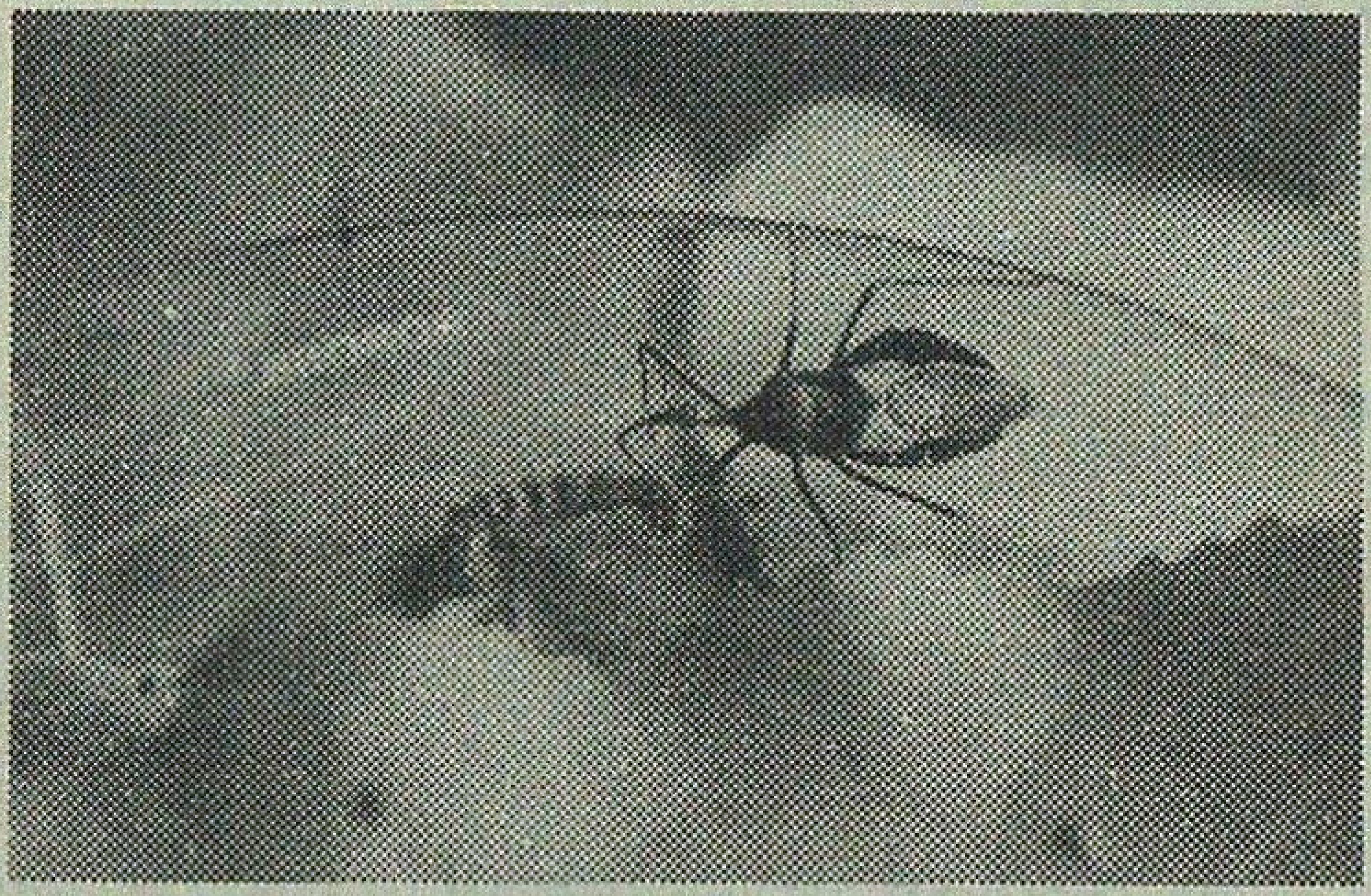
(IV)

SYCANUS COLLARIS FABR. (REDUVIIDAE : HEMIPTERA), A NEW PREDATOR OF *CLOSTERA* SPP. ON *POPULUS DELTOIDES*

Sycanus collaris Fabr. (Fig.1) is found in the Oriental region including Assam, North Khasi Hills, Ceylon, Malayan peninsula and several islands of Malayan Archipelago (Distant, 1903; Beeson, 1941). It has been known to predate on Teak defoliators, *Eutectona machaeralis* and *Hyblaea peura*, Shisham defoliator, *Plecoptera reflexa*, on some other defoliators namely *Margaronia laticostalis* on *Holarrhena antidysenterica* and *Nephopteryx rhodobasalis* on *Cassia fistula* (Beeson, 1941). It also predates on tasar silkworm *Antheraea mylitta* (Singh, 1986).

These predatory bugs were also observed predating on the larvae of *Clostera cupreata* and *C. fulgurita* on *P. deltoides* grown in nurseries near Chutmalpur, Saharanpur Forest Division, U.P. during September, 1997. A large number of these bugs were seen, flying and setting on leaves in the top portion of 1 to 2 year old plants. The bugs were seen searching for the pest larvae and predating on them. *S. collaris* also carried the host larvae while moving. It's presence in the nursery was greater then *Canthecona furcellata* which was also present and predated on *Clostera* spp. larvae.

Fig. 1



Sycanus collaris predating on the larvae of *Clostera fulgurita*

S. collaris was easily reared in the laboratory. The adults preferred 3rd, 4th and 5th instar host larvae for feeding and consumed a maximum of 1 larva/day.

Owing to its larger adult size as compared to *C. furcellata*, good predation and reproductive potential (Beeson,1941), vast distribution (Distant, 1903) and easiness to rear in the laboratory, this bug can be exploited as a possible biological control agent against *Clostera* spp. on Poplars in Northern India.

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Arun P. Singh

LETTER TO THE EDITOR

To
The Hony. Editor,
Indian Forester,
P.O. New Forest,
Dehra Dun (U.P.)

Sub : **Watershed Management in M.P. Forests**

Sir,

I have read with interest the "Letter to the Editor", with the above caption written by Shri S.S. Chitwadgi, I.F.S. (Retd). appearing in the *Indian Forester* in the July'97 issue and have ventured to make the following observation without any bias to anybody :

1. Shri Chitwadgi has written that "in M.P. and all other States, invariably forests are covered by Govt. approved Working Plan". In fact, not all forests are covered by Working Plans. Only the Reserved Forests are covered by Working Plans. The unclassed, protected and private forests etc. are not covered by Working Plans in our State at least. Probably it is equally true in other States too.

2. In the second paragraph of his letter, Shri Chitwadgi has very rightly mentioned that "These operations prescribed when carried out as per prescriptions are then recorded in "Control Form...".

3. In the third paragraph, contrary to his above remarks he has observed that acts which find no expressions in the prescribed approved plan and which he has called "irregular activities" should also go in concerned compartment history and in Control forms.

   I have some reservations in this regard. The nomenclature "irregular activities" appears to be a misnomer. The irregular activities in the reserved forests, mainly in the form of watershed rehabilitation works, must surely have the prior approval of the Govt. and the Forest Department and hence regularised. Instead of entering these so-called "irregular activities" in the prescribed Working Plan Compartment Histories and Control Forms, a separate record should be maintained for these operations quoting *post facto* sanction of Govt. for them. This will help the Department know at a glance the quantity and the kind of forest produce removed outside Working Plan prescriptions.

4. Shri Chitwadgi has mentioned about a rather serious irregularity in para 4 of his letter

alleging that same forest area being closed to road, is planted several times, disregarding the urgent needs of other areas. But how can it be done when there is a Working Plan fixing areas for each year's fellings and plantings?

Also how entries of such irregular plantings are made in compartment histories and control forms? His observations that compartment histories are not brought upto date and Working Plan revisions do not take these facts need personal attentions of State's Principal Chief Conservator of Forests - whom Shri Chitwadgi should have intimated instead of publishing in the *Indian Forester*, as he was in service for a long period.

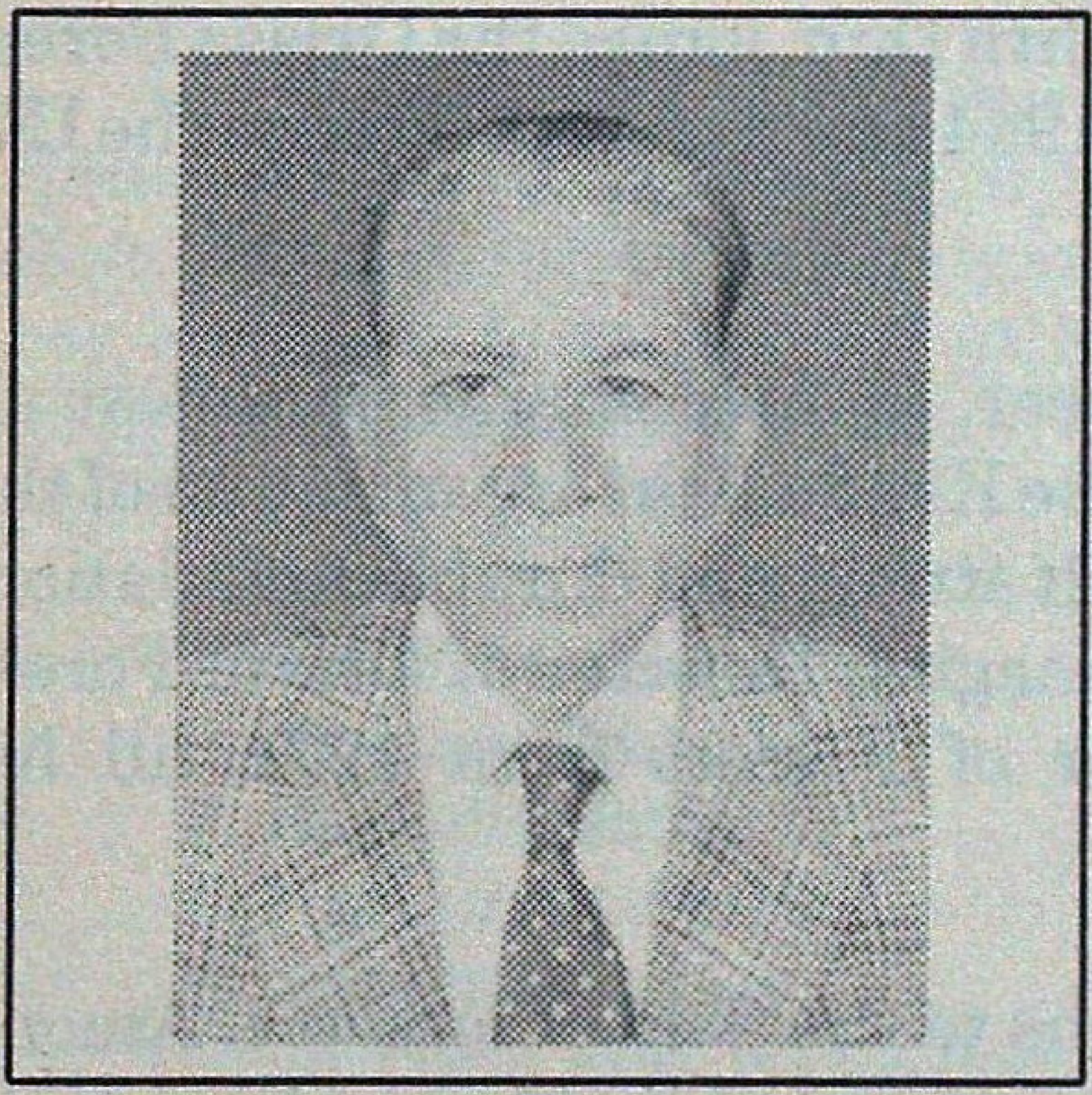
5. The writings of Shri Chitwadgi in the last three paras, specially in the last para to the effect that "presently the Forest Department appears to be condemned so far as Watershed Management Works in forests are concerned" appear that he is ventilating some grievances against the present set-up of his old department.

T.R. Mohanta, I.F.S. (Retd.)
Jorhat (Assam)

OBITUARIES

(I)

Dinkar Hansraj Kulkarni
(11-7-1917 - 1-9-1997)



It is with profound sorrow that we record the sad demise of Shri D.H. Kulkarni, I.F.S. (Retd.) on Ist September, 1997 at his residence at Nagpur.

Shri Kulkarni was educated at Pandharkawada and Nagpur. He joined the Indian Forest College, Dehra Dun and belonged to the 1940-42 batch. He served C.P. and Berar Province and Madhya Pradesh for about 18 years. He was appointed the Dean, Indian Forest College and held the post from 1957 to 1964. He was also Dy. Inspector General of Forests from 1964 to 1968. Later he joined the F.A.O. and served in the West Indies for 9 years. He was a visiting Professor to the Oregon University, U.S.A. He also served in the Union Public Service Commission and Forest Development Corporation of Maharashtra Ltd.

Forestry was his passion. He wished in his will that after his death, his ashes be immersed in the Bori River in Bori Forests where he started his career as a Forest Officer. The famous Working Plan of Bori Reserved Forest, prepared by him is well known.

May his soul rest in peace.

-M.S.R.

(II)

Sreepal Jee

(8-4-1920 - 23-12-1996)

Shri Sreepal Jee, the former Chief Conservator of Forests Orissa, passed away on the 23rd December, 1996 after a brief illness.

Shri Sreepal Jee graduated with honours and after successful completion of training in the 1942-44 batch of the Forest Service Course at Dehra Dun, joined the Orissa Forest Department as an Assistant Conservator of Forests in 1944 and was appointed to the IFS at its initial constitution in 1966.

During his 34 years of distinguished service career, he held charge of almost all important posts in the State. He was the first to head the Kendu Leaf organisation of the State after its nationalisation, led it to success and built strong and durable foundation, which was emulated by other States. He was the Managing Director of Orissa Forest Corporation and later served as Chief Conservator of Forests from 1974 till his retirement in 1978.

Shri Sreepal Jee made many notable contributions to the field of forestry. Among these are the first regular working plan for the forests of erstwhile Mayurbhanj state after merger, which included the Similipahar forests. His sincere and pioneering efforts to protect the teak bearing areas on Government lands in the erstwhile Kalahandi state after its merger which had fallen prey in private hands; his firm and uncompromising stand to prevent clearfelling and planting of Similipahar forests by tropical pines which was a craze at that time, will long be remembered. He laid the ground for the first Social Forestry project under the aegis of I.R.D.P. in Puri District during 1976-78 before any externally aided project was sanctioned any where in the country. He was instrumental in preparation of a shelf of bankable projects for institutional finance and construction of a chain of beautiful forest Rest Houses in different parts of the State, notable among these being the Chandipur Forest Rest House on Balasore coast, which he literally retrieved from ashes and rebuilt under his personal supervision.

He was a strong, honest, dedicated, disciplined and fearless administrator, who could not be shaken by the strong winds blowing against him from various directions and stood "like flame in a windless spot that did nor flicker". His affection was spontaneous.

He leaves behind four sons (his wife having passed away earlier) and a host of friends, colleagues and subordinates to mourn his loss.

May his soul rest in peace.

-R.N.M.

GAZETTE NOTIFICATIONS

ANDHRA PRADESH GAZETTE

Shri M.Sudhakar, I.F.S. (1983), Project Director, District Rural Development Agency, Srikakulam is promoted to the Supertime scale of I.F.S. in the rank of Conservator of Forests in the scale of pay of Rs. 16,400-450-20,000/- (pre-revised scale of pay of Rs. 4500-150-5700/-). On promotion he is posted as Addl. Commissioner, Relief, Office of the Commissioner, Relief vice Dr. C. Umamalleswara Rao, Addl. Secretary to Govt, Revenue Department, relieving from the Additional charge.

Under rule 10(a) of A.P. State and Subordinate Services Rules, the following Forest Range Officers are appointed temporarily to the post of Assistant Conservator of Forests with immediate effect. The appointment is purely temporary and on ad-hoc basis without any right of probation and they are liable to be reverted as Forest Range Officers at any time without notice and without assigning any reasons therefor:

S/Shri

1) Mohd. Samiullah Khan
2) S. Venkata Ramana
3) P. Badusha Saheb
4) A. Narasimha Murthy
5) K. Pradeep
6) N. Venkata Ram Narasaiah
7) T. Ramesh Babu
8) P. Peddi Raju
9) S. Rama Rao

KARNATAKA GAZETTE

In exercise of the powers conferred by Rule 4 of the Indian Forest Service (Probation) Rules, 1968, the President is pleased to confirm the following directly recruited Officers, borne on the Karnataka cadre, in the Indian Forest Service with effect from the dates indicated against their names:

S.No.	Name	Date of appointment	Date of confirmation
1.	Shri Jagmohan Sharma	20.08.90	20.08.93
2.	Shri Ramachandra	20.08.90	20.08.93
3.	Shri Dilip Kumar Das	15.09.91	15.09.94
4.	B.P. Ravi	11.10.92	11.10.95
5.	Shri H.S.S. Murthy	01.01.93	01.01.96
6.	Smt. Seema Garg	20.08.90	20.08.93
7.	Shri Rajkumar Srivastava	15.09.91	15.09.94
8.	Shri Brijesh Kumar	01.01.93	01.01.96
9.	Smt. A. Radhadevi	01.01.93	01.01.96

WEST BENGAL GAZETTE

Shri T.V. Narsimha Rao, I.F.S. has taken over charge of Divisional Manager Kalimpong (General & Special) Division, West Bengal Forest Development Corporation Limited from Shri P. Shukla, I.F.S. in the afternoon of 23.12.1997.

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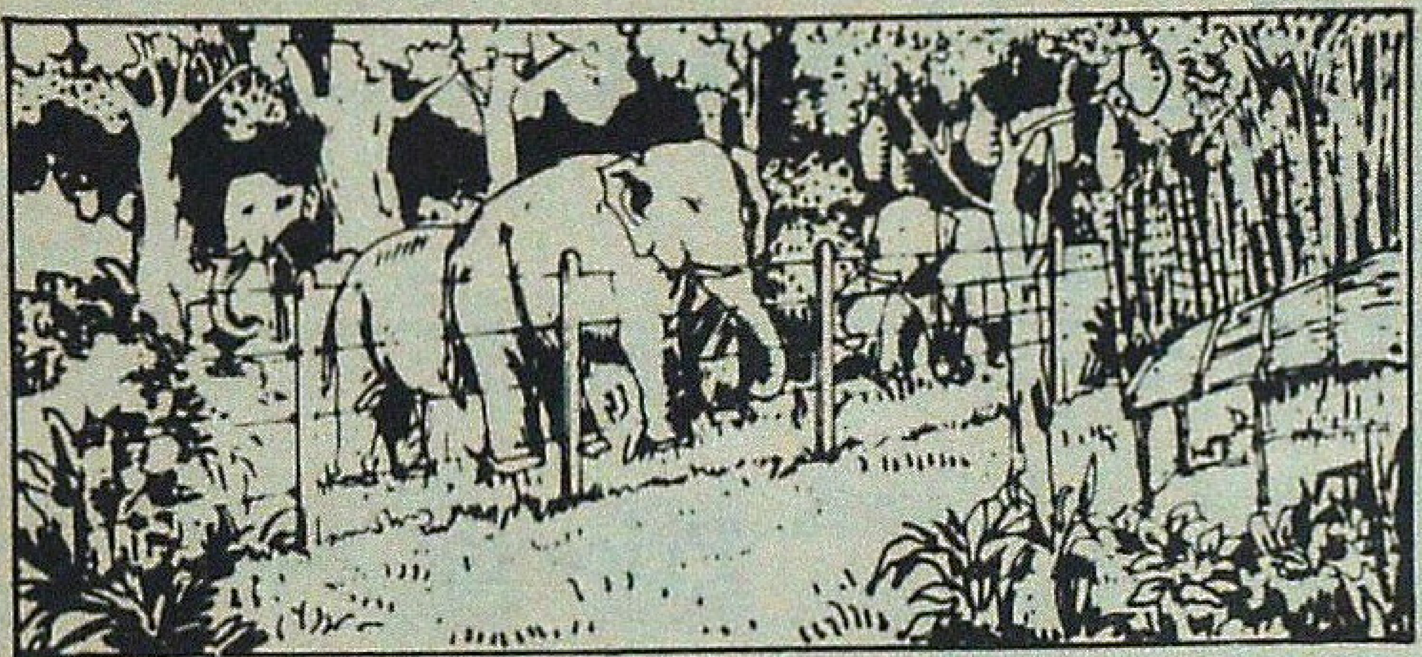

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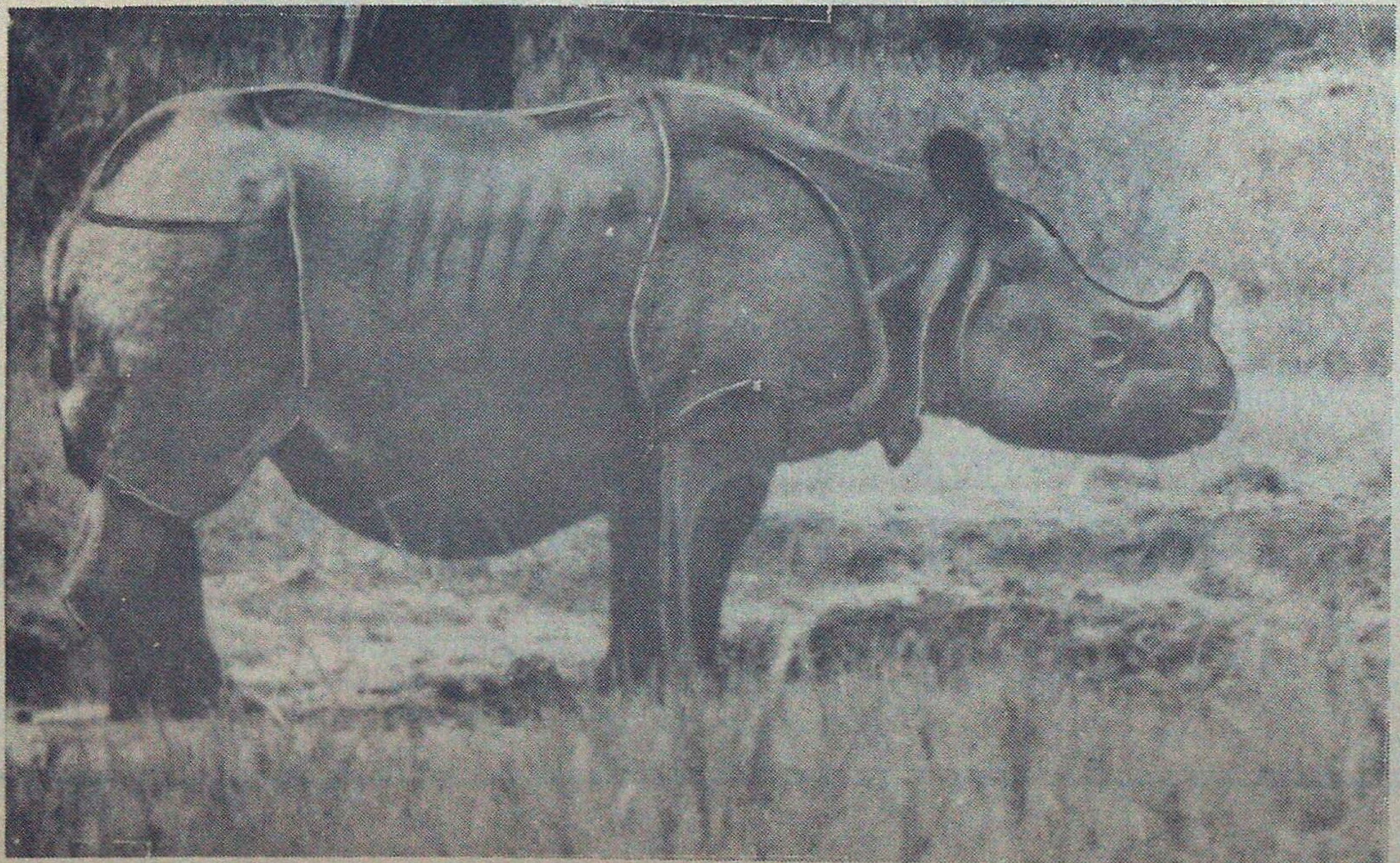

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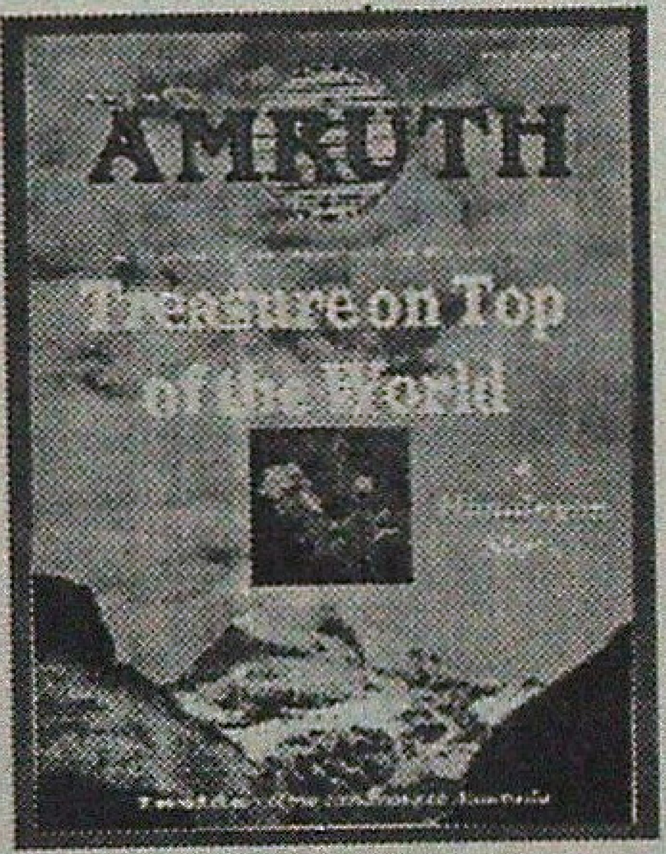

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		Debal-Wan-Roopkund-Ghat	70 km
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		Munsyari-Milam-Milam Glacier	60 km
3. Almora	:	Pindari Glacier	
		Loharkhet-Khati-Pindari Glacier	50 km

BEST VISITING TIME : 15TH JUNE - 15TH OCTOBER

For More Information Contact

Deputy Conservator of Forest
Nanda Devi National Park
Joshimath (Chamoli)
Ph : 22179

Joint Director
Nanda Devi Biosphere Reserve
Gopeshwar (Chamoli)
Ph : 52497

Tamil Nadu Forest Plantation Corporation Limited

(A Govt. of Tamilnadu Undertaking)

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Tamil Nadu.

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(P) 469352
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For further details, please contact Vice President (Plantations):

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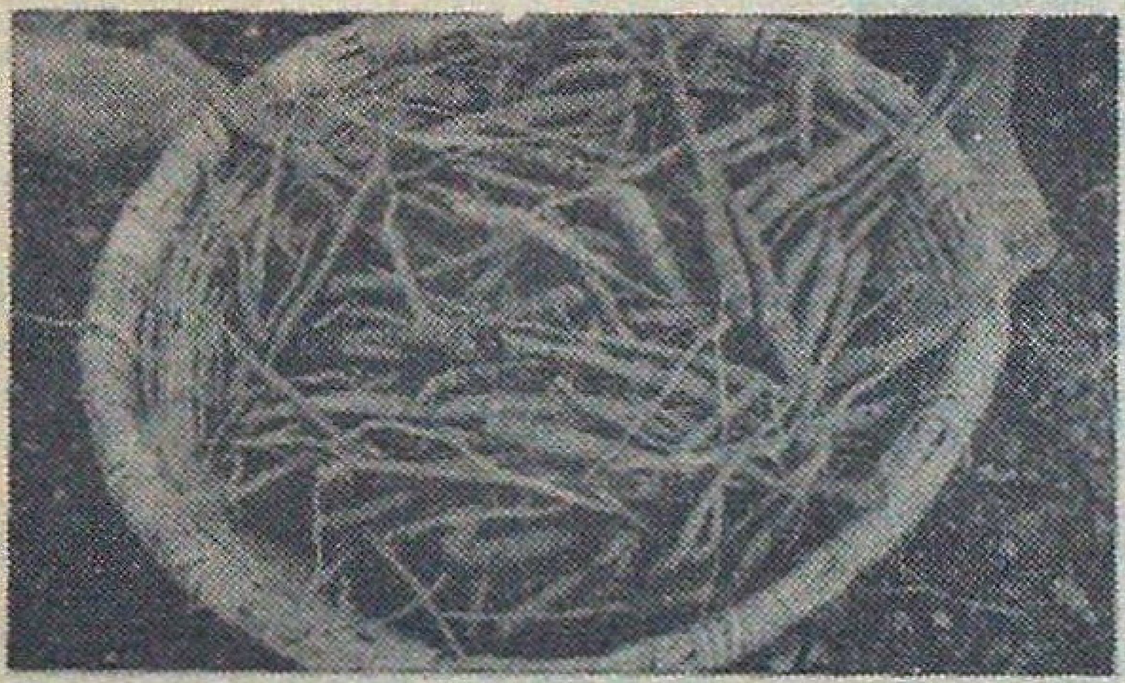

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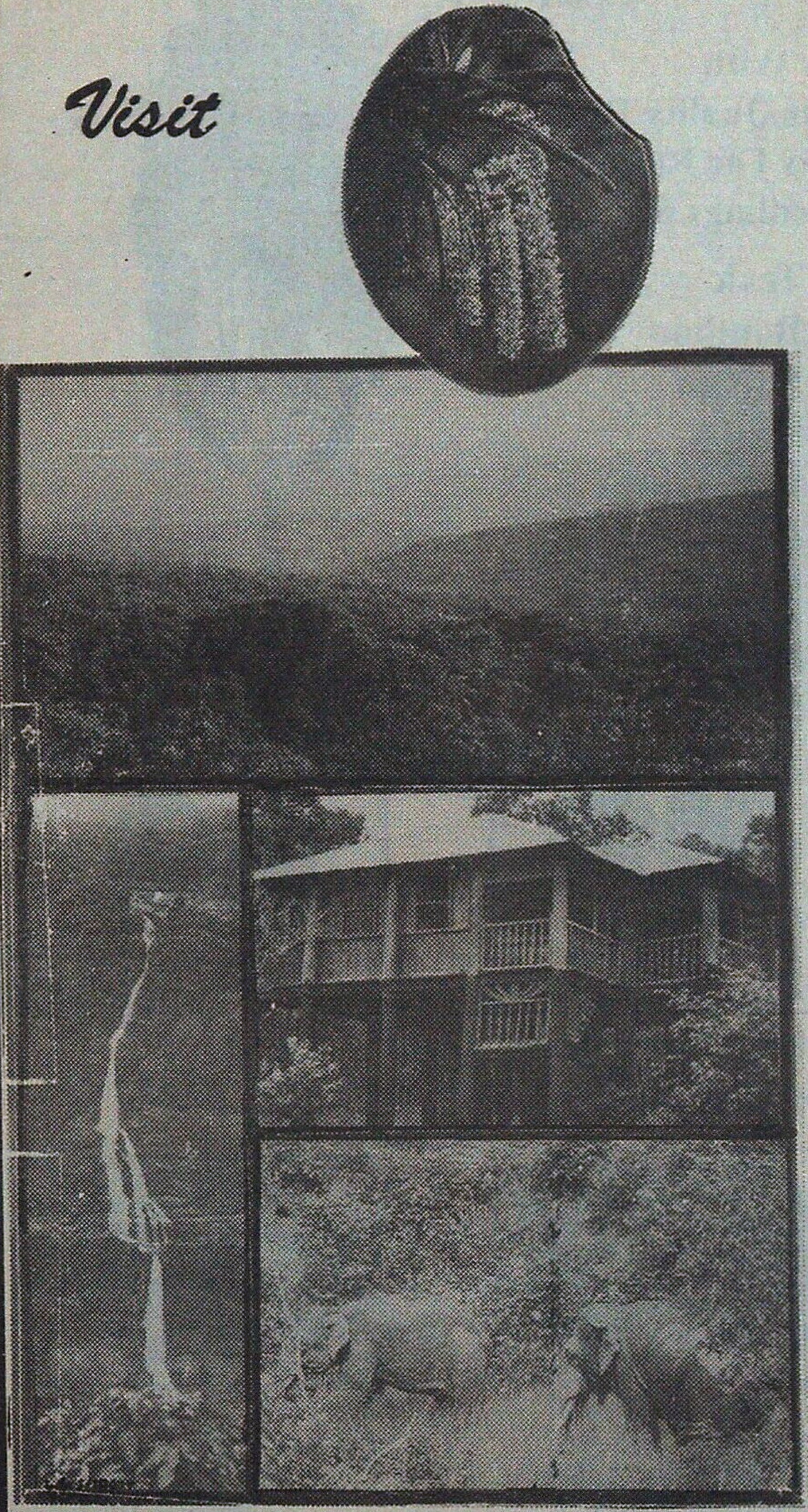

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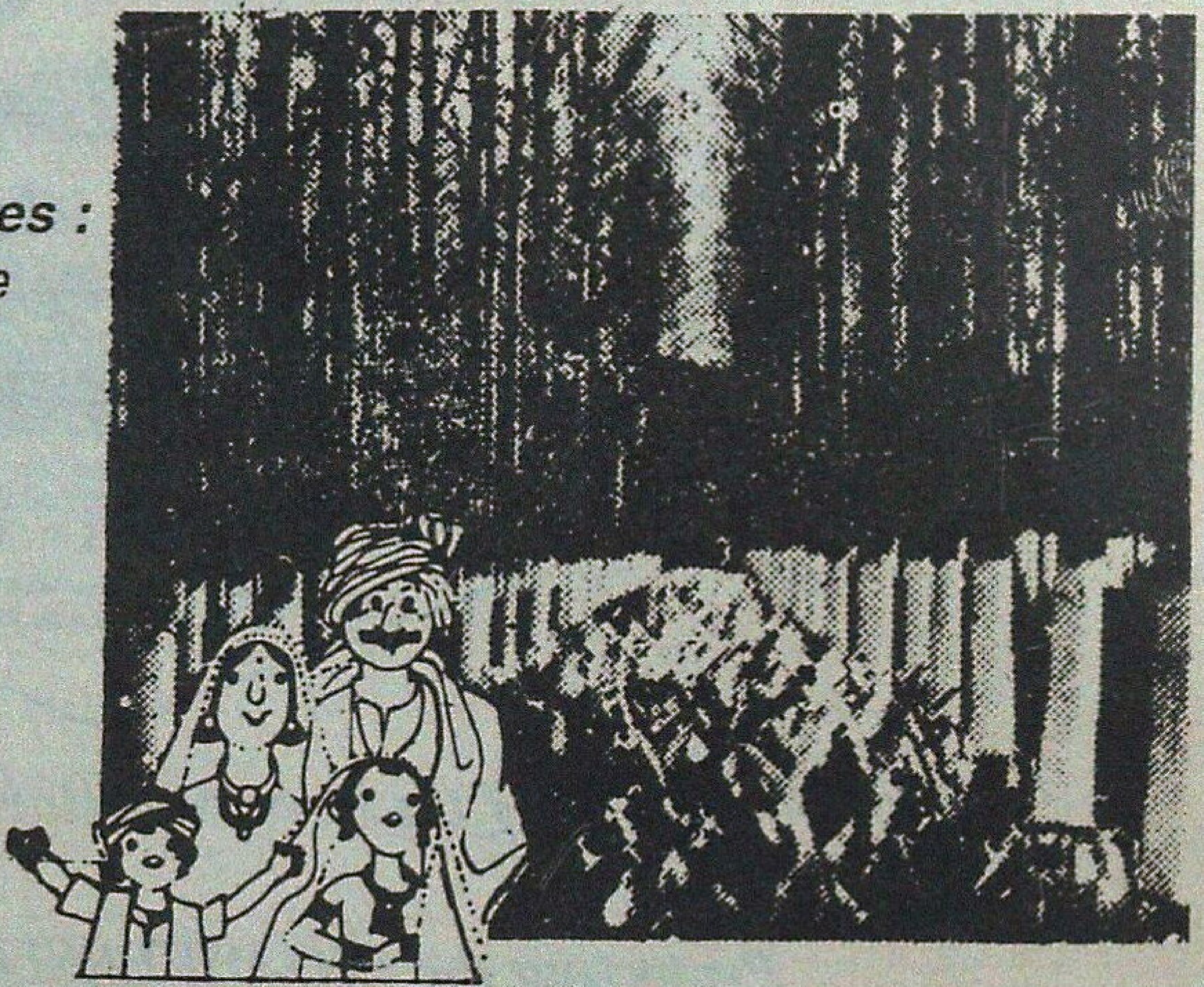

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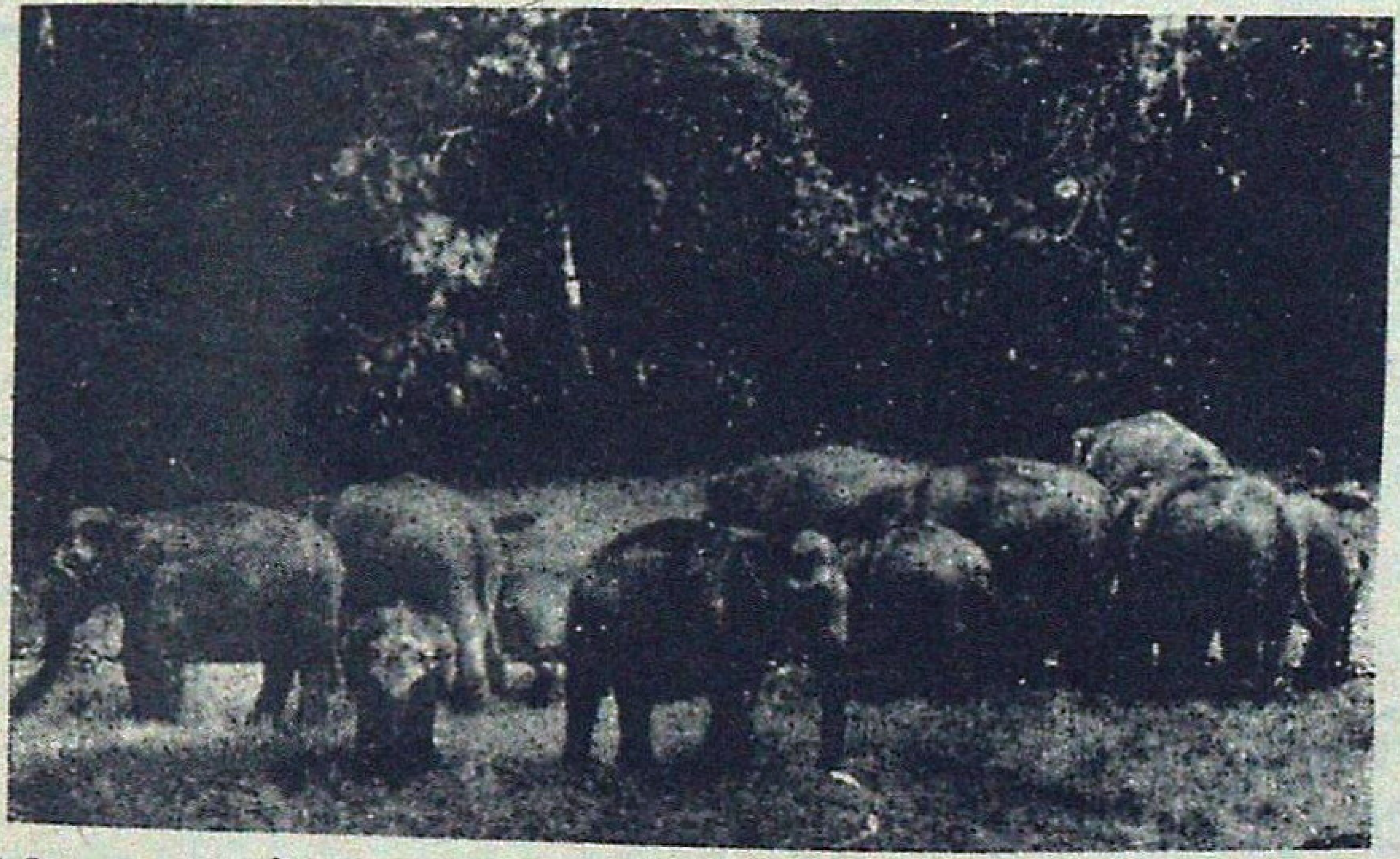

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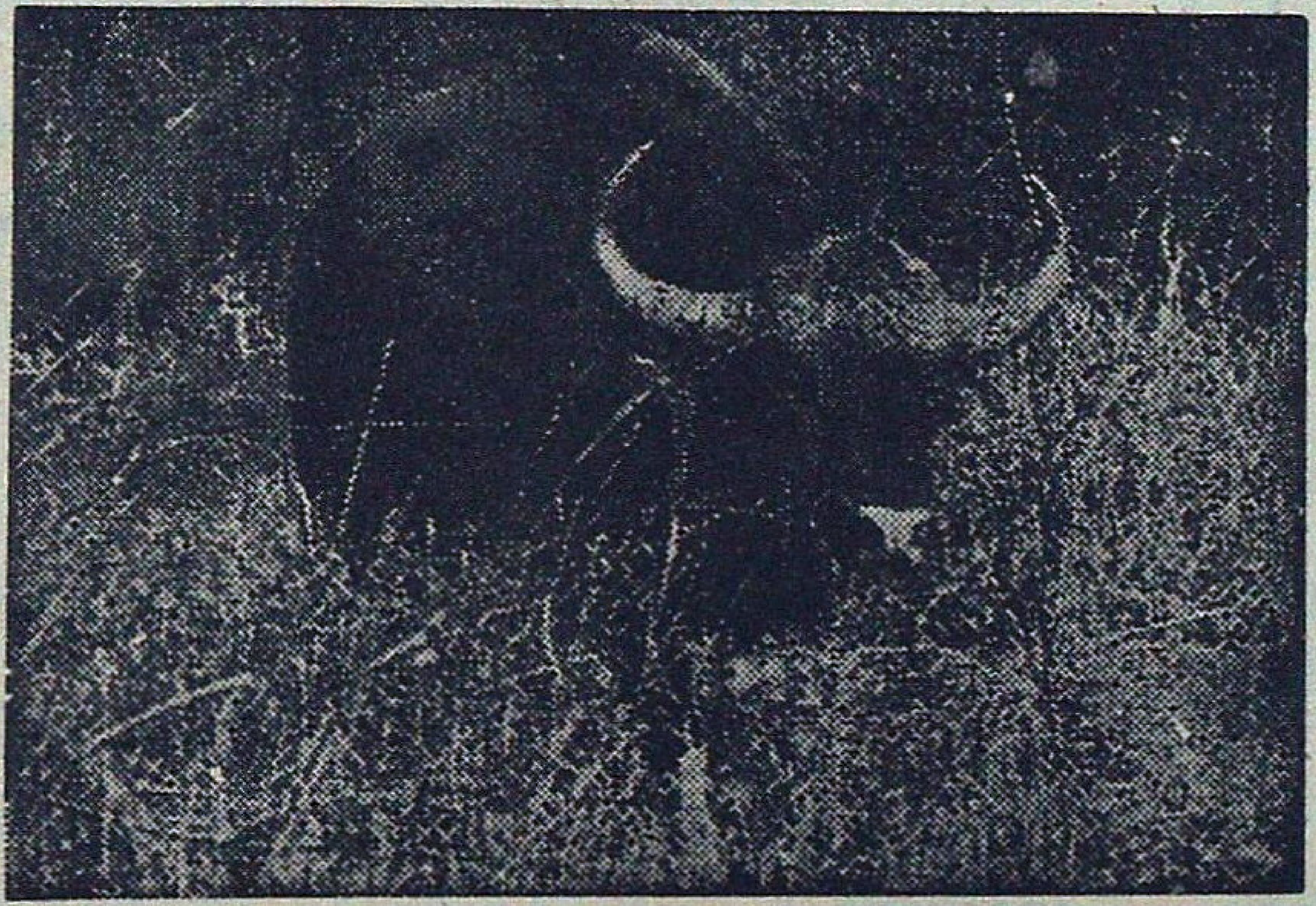

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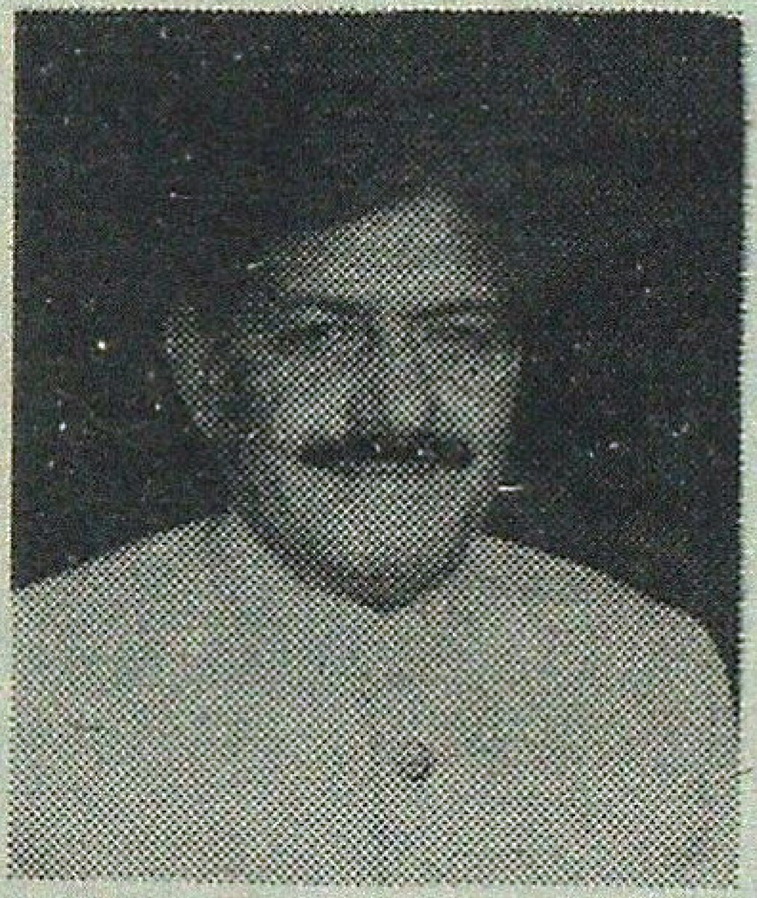

Shri Natha Singh
Vice Chairman, HPSFC Ltd.

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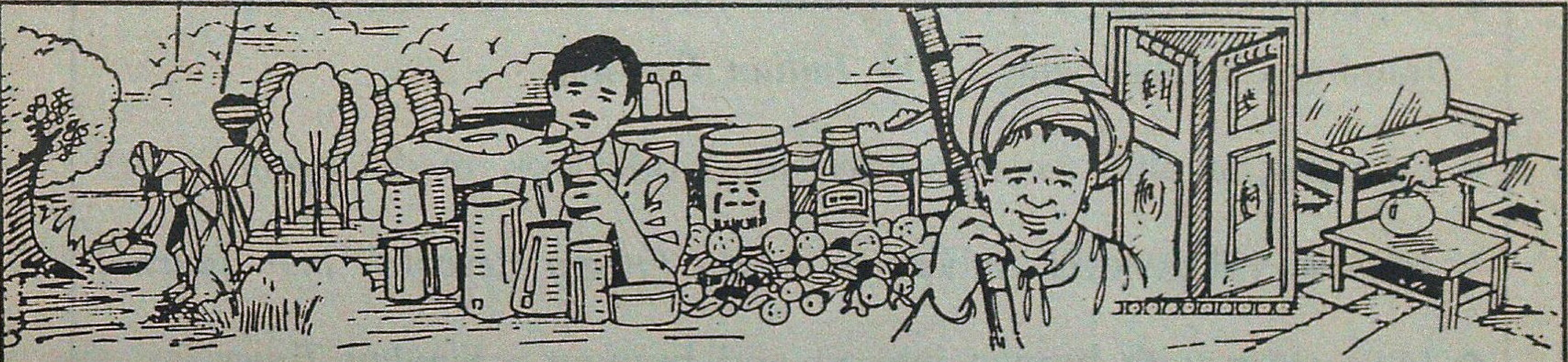

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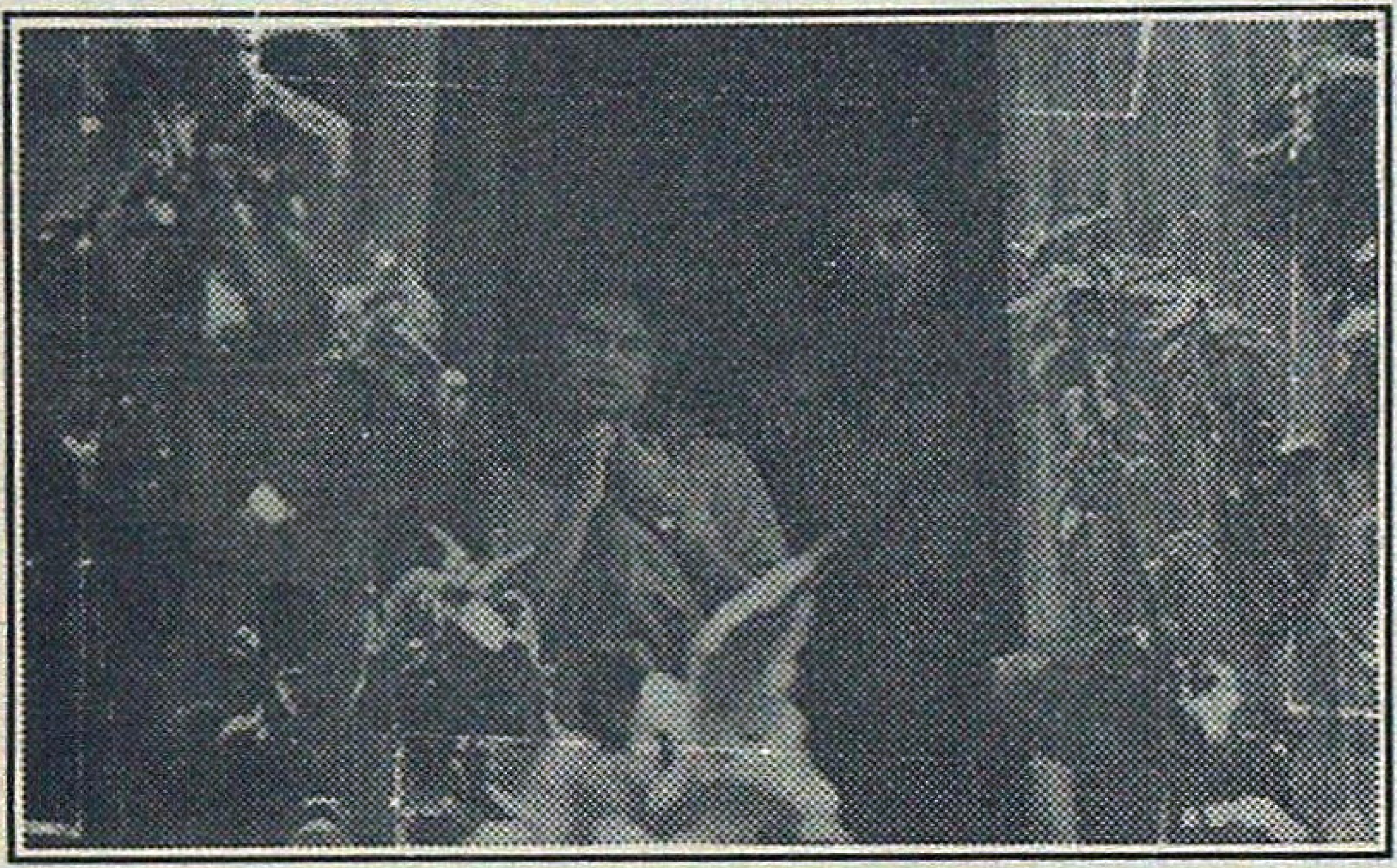

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